TECHNICAL MEMORANDUM NO 9

HUMAN HEALTH RISK ASSESSMENT
903 PAD, MOUND, AND EAST TRENCHES AREAS
OPERABLE UNIT NO 2
CHEMICALS OF CONCERN

DRAFT

ROCKY FLATS PLANT

U S DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

ENVIRONMENTAL MANAGEMENT DEPARTMENT

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ADMIN RECORD

REVIEWED FOR CLASSIFICATION
BY G... 6?
DATE 8-9-93

LIST OF APPENDIXES

LIST OF TABLES

LIST OF FIGURES

1.0
INTRODUCTION

This Chemicals of Concern Technical Memorandum is presented as part of the Baseline Risk Assessment (BRA) for the 903 Pad, Mound Area, and East Trenches Area, otherwise known as Operable Unit 2 (OU-2), located at Rocky Flats Plant The BRA, which consists of the Human Health Risk Assessment (HHRA) and the Environmental Evaluation, will be included in the Phase II RCRA Facility Investigation/Remedial Investigation (RFI/RI) report for OU-2 The RFI/RI is being conducted pursuant to the U S Department of Energy (DOE) Environmental Restoration Program, a Compliance Agreement between DOE, the U S Environmental Protection Agency (EPA), and the State of Colorado Department of Health (CDH), and the Federal Facility Agreement and Consent Order (Interagency Agreement), signed in 1991

This technical memorandum has been developed to address the selection of chemicals of concern to be evaluated in the BRA, in particular the HHRA The identification of chemicals of concern will also help focus the efforts of the Environmental Evaluation, environmental transport modeling, description of nature and extent of contamination, and remedy selection

The HHRA will evaluate potential human health risks for on-site and off-site receptors under current land use and probable future land use conditions, assuming no remedial action takes place at OU-2 Chemicals of concern are site-related chemicals or radionuclides (i e , those that are potentially related to sources in OU-2), that exceed background range, and that could be a significant threat to human health or the environment under the exposure conditions evaluated Chemicals of concern are identified for each medium (e g , groundwater, soil, or air) through which exposure to site-related chemicals could occur Therefore, the selection of chemicals of concern supports the quantification of risk from exposure to chemicals via the exposure pathways identified in the Exposure Scenarios Technical Memorandum No 5 (EG&G 1993)

This technical memorandum focusses on selecting chemicals of concern in groundwater, subsurface soil, and surface soil, which were the media sampled during the Phase I and Phase II RFI/RI at OU-2 Exposures can also occur through the air and surface water pathways Chemicals of concern for air and surface water are those detected in soil or groundwater that could be transported by air or could migrate from soil or groundwater to surface water exposure points

This Technical Memorandum describes the process for selecting chemicals and radionuclides of concern detected in groundwater, subsurface soil, and surface soil at OU-2 and summarizes the chemicals and radionuclides of concern for each medium The general process to select potential chemicals of concern in groundwater, subsurface and surface soils is described in Section 2 0 Sections 3 0, 4 0 and 5 0 present decision criteria specific to each medium and identify the chemicals of concern selected for each medium. References used in this document are provided in Section 6 0

Appendix A, "Background Comparison for Metals and Radionuclides," describes the statistical methodology used to compare OU-2 data to background data to identify metals and radionuclides whose concentrations exceed background levels and which may therefore be site-related These metals and radionuclides are retained for further evaluation as potential chemicals of concern

Appendix B, "Risk-Based Evaluation of Low-Frequency Compounds," presents the screening of infrequently detected compounds (<5 percent detection frequency) to identify those that merit further evaluation as potential chemicals of concern

Appendix C contains a copy of the OU-2 report titled "Domestic Water Supply Simulations," September 10, 1992 This document supports the identification of the No 1 sandstone lithologic unit for evaluation of hypothetical on-site ingestion of groundwater

2.0
CHEMICALS OF CONCERN SELECTION PROCESS

The general methodology for selecting chemicals of concern for OU-2 is presented in Figure 2-1, Criteria for Identifying Chemicals of Concern The process is intended to identify chemicals in each medium that appear to be associated with sources in OU-2 and could have adverse impacts on public health under exposure conditions involving that medium In this way, the risk assessment is focussed on OU-2 constituents that are potential health hazards Inorganic compounds whose concentrations are within background range or minor constituents (e g , rarely detected and/or of low toxicity) that would contribute negligibly or not at all to overall risk are identified but are not included in the quantitative risk assessment It is important that the chemicals of concern be carefully selected so that risk is not underestimated and so as not to distract from the dominant risks associated with the site

This selection process was based on guidance presented in Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part A (EPA 1989a) The background comparison methodology was based on the Final Background Geochemical Characterization Report, Rocky Flats Plant (EG&G 1992a) and on standard statistical evaluation techniques

The steps shown in Figure 2-1 and described in the following sections were applied to select chemicals of concern for all three media (groundwater, subsurface soil, and surface soil) Details of the application of the process for each medium are presented in Sections 3 0 (groundwater), 4 0 (subsurface soil), and 5 0 (surface soil)

The individual steps shown in Figure 2-1 are identified below Each step is described in more detail in subsections 2 1 through 2 5

Step 1 - Site-Specific Chemical Analysis Roster

Table 2-1 is the Site-Specific Chemical Analysis Roster (SSCAR) for the Phase II sampling program at OU-2 Analytical results for all detected compounds in the following analyte groups are included in the data set for evaluation as potential chemicals of concern for risk assessment metals (target analyte list and "other metals"), radionuclides, and organics

Step 2 - Data Evaluation

The analytical results from the OU-2 sampling program were reviewed and compiled in a database by the validation contractor Data validation was performed for some but not all of the data prior to use The database was then reviewed for its suitability for selecting chemicals of concern For example, data qualifiers were considered and quality control samples were removed from the database

Step 3 - Background Comparison (Metals and Radionuclides)

Analytical results for metals and radionuclides were compared to background levels Those that did not exceed background were eliminated from further consideration as potential chemicals of concern The following criteria were used to evaluate whether a metal or radionuclide exceeded background levels

a Analytical results for metals and radionuclides were compared to the 95 percent upper tolerance limit (95% UTL) of the background data If less than 5 percent of the results exceeded the 95% UTL, the constituent was considered to be within background range. Analysis of variance (ANOVA) was used to confirm this assessment

b The OU-2 data for metals and radionuclides were statistically compared to background data from the Background Geochemical Characterization Report (EG&G 1992a) using analysis of variance (ANOVA) If no statistical difference was found, the analyte was considered to be within background range

c Spatial/temporal evaluation of analytes that appear to exceed background was performed to identify those that are unlikely to be related to sources in OU-2

Step 4 - Eliminate essential nutrients and anions

Constituents such as calcium, potassium, iron, and carbonate were eliminated from further consideration as chemicals of concern due to low toxicity

Step 5 - Detection Frequency

All detected organic target analytes and inorganic constituents above background levels were separated into two groups based on detection frequency Compounds detected at 5 percent or greater detection frequency were evaluated further in Step 6 Contaminants detected below 5 percent frequency were evaluated in Steps 8 and 9

Step 6 - Concentration/Toxicity Screen

A concentration/toxicity screen, using maximum detected concentrations and EPA-established toxicity factors, was performed on all organic chemicals with a detection frequency equal to or greater than 5 percent and on metals and radionuclides that exceed background levels to identify those compounds that are likely to contribute 99 percent or more of total risk These are identified as chemicals of concern

Step 7 - Chemicals of Concern

Organic chemicals, metals and radionuclides that contribute 99 percent or more of a total risk factor, based on Step 6, were retained as chemicals of concern for quantitative evaluation in the human health risk assessment

Step 8 - Evaluation of Infrequently Detected Compounds

The maximum concentration of each organic compound detected at less than 5 percent frequency was compared to a screening-level concentration equivalent to 1000 times a health risk-based concentration (RBC) This step identifies infrequently detected compounds that would contribute significantly to total risk if long-term exposure were to occur

Step 9 - Spatial and Temporal Evaluation of Infrequently Detected but Potentially Hazardous Compounds

Infrequently detected compounds whose maximum concentration exceeded 1000 times the RBC were evaluated for spatial and temporal distribution of the detected values If the compounds were detected in association with other contaminants, or if spatial and temporal distribution (in groundwater) indicated that the constituent is of potential concern for current or future exposures, these chemicals were retained as "special-case" chemicals of concern

Step 10 - Special Case Chemicals of Concern

Compounds whose maximum concentration exceeded the screening values (Step 8) and with significant spatial and temporal distributions (e g, detected in association with elevated concentrations of other chemicals of concern) (Step 9) were retained as "special case" chemicals of concern to be addressed separately in the risk assessment,

Step 11 - Professional Judgment

Chemicals or radionuclides that were eliminated as chemicals of concern by the above criteria may be retained on the basis of professional judgment

2.1 DATA EVALUATION

Table 2-2, OU-2 Analytical Data File Summary, presents the data files used to select chemicals of concern for OU-2 For groundwater, six quarters of monitoring data (2nd quarter 1991 through 3rd quarter 1992) were used, based on at least 50 percent of the data being validated (fewer of the earlier data were validated) For subsurface soil (borehole), data from samples collected above the high water table in 1987 (Western Phase I data) and in 1991 and 1992 (W-C) were used The 1987 Phase I borehole data are not validated Borehole samples collected below the high water table were not used to avoid the potential problem of cross-contamination from groundwater biasing the selection of soil chemicals of concern Surface soil data collected in 1991 (Stoller) and 1993 (W-C) were included in the data set As of June 1993, approximately the following amount of 1993 surface soil data has been received semivolatile organics (100%), pesticides (100%), metals (18%), and radionuclides (48%)

Some of the chemical analytical results have not been validated Unvalidated data received from Rocky Flats Environmental Data System (RFEDS) were integrated with validated data received from Quantalex Laboratory If unvalidated and validated data for the same sample were found in the database, the unvalidated data were eliminated Data that had not yet been through the validation process were used if no validated data were available

Lithologic identifications for the groundwater monitoring data were determined, and only wells completed in the Upper Hydrostratigraphic Unit (UHSU) are included in the groundwater data set The UHSU includes the alluvium, colluvium, valley fill, and the uppermost Arapahoe Sandstone The OU-2 bedrock investigation (DOE 1993a) will address any potential contamination of the Lower HSU (LHSU) Chemicals of concern for assessing potential human health risk from on-site groundwater ingestion were selected from analytes detected in the uppermost Arapahoe sandstone This is based on the finding, presented in the OU-2 Water Supply Simulations document (Appendix C), that the uppermost Arapahoe sandstone is the only lithologic unit that could support a domestic water well (see Appendix C)

Groundwater data from the alluvium, colluvium, valley fill, and No 1 sandstone were aggregated for evaluating migration of contaminants in groundwater to potential exposure points in Woman Creek and Walnut Creek

The next step in the data evaluation process was to remove quality control samples, such as blanks, spikes, rinsates, from the database Data qualifiers for chemicals (e g , B, E, D and R) were identified and the following revisions to the database were made

- E qualified data (exceeded calibration range) were replaced with the associated D qualified data (diluted to within calibration range) The E qualifier for metal analytical results indicates that the reported value was estimated due to interference These data were used as reported

- The B qualifier assigned to an organic compound (volatile, semivolatile, pesticide, or polychlorinated biphenyl (PCB)) signifies that the compound was found in both the sample and the associated laboratory blank For validated data, if the reported sample concentration for a B qualified compound that is not a common laboratory contaminant was greater than five times the reported concentration in the blank, the analytical result was used as reported If not, the result was qualified with a U by the validation contractor and the result qualified as a nondetect at the reported value If the reported sample concentration for a B qualified compound that is a common laboratory contaminant (e g, methylene chloride, 2-butanone, bis(2-ethylhexyl phthalate) was greater than ten times the reported concentration in the blank, the analytical result was used as reported If not, the result was qualified with a U by the validation contractor and the result reported as non-detect at the reported value

  For non-validated data, B qualified results have been reported in the database, however, there was no connection in the database between non-validated B qualified results and the associated laboratory blanks or rinsate blanks Because the effect of blank contamination on the B qualified results could not be assessed, the non-validated B qualified results were not included in the working database for selection of chemicals of concern The removal of these unvalidated B-qualified results from the working database does not adversely impact the useability of the data for selection of chemicals of concern for the following reasons (1) relatively few results were removed (000 from a total of 00000-*to be determined*), (2) all (?) the results that were removed were B-qualified results for common laboratory contaminants (e g , acetone, methylene chloride, and bis(2-ethylhexyl)phthalate), (3) in the validated data set, most B-qualified results for common laboratory contaminants were changed to U qualified results (non-detect) during validation, so it is probable that most of the other B qualified results would also have been qualified as non-detect The net effect is to change the frequency of detection of common laboratory contaminants by a small percentage because the number of samples is reduced by the number of results removed for each analyte This is not considered to adversely affect the identification of site-related chemicals of concern for risk assessment

The B qualifier for a metal result signifies that the reported concentration is greater than the instrument detection limit but less than the Contract Required Quantitation Limit (CRQL) for that analyte These data were used as reported

- R qualified data (not usable according to EPA criteria) were eliminated

  R-qualified results represent a very small fraction of the entire data set R-qualified results only appear in validated data

Data qualified with J or U were used as follows

- Analytical results were J qualified if the compound was positively identified below the CRQL The result was considered an estimate because of the uncertainty associated with detected concentrations at low levels Data qualified with a J were used as reported

- A U qualifier assigned to an analytical result indicates that the analyzed chemical was not detected above the sample quantitation limit The U qualifier was the primary mechanism used for evaluating detection frequency for the organic and inorganic constituents The U qualified data were used as non-detects for detection frequency determination, but one-half the reporting limit was used as the result for statistical evaluation in the ANOVA evaluation

There were numerous instances where multiple analytical results for a given sample were reported in the RFEDS database Circumstances that may have resulted in multiple results being reported and the action taken during review of the database include

- Validated and non-validated results were reported for the same sample In all cases where a validated and non-validated sample result were reported, the result from the validated record was retained in the database

- Results from multiple dilutions were reported for the same sample Multiple dilutions were typically reported for the analyses for volatile and semivolatile organics due to one or more analytes exceeding the calibration range for the initial analysis In cases where the result was flagged with an E qualifier by the laboratory, the action taken was as described above In cases where non-detects were reported for an analyte in both the initial and diluted samples, the value with the lower detection limit was retained In cases where the results were reported as detected in both the initial and diluted samples, the higher value was retained in the database.

- Results from both an initial analysis and a re-analysis and/or re-extraction were reported for the same sample For non-validated results, the reason for the re-analysis or re-extraction were not reported (e g , calibration, surrogates, internal standard areas) and it was not possible to determine if the problem requiring the re-analysis was corrected or if the re-analysis was performed within holding times Therefore, in cases where non-detects were reported for an analyte in both the initial and re-analyzed samples, the value with the lower detection limit was retained In cases where the results were reported as detected in both the initial and re-analyzed samples, the higher value was retained in the database

For radionuclides, negative values were considered non-detect, and values less than the laboratory reporting limit were used as positive results or non-detects in accordance with qualifiers assigned during data validation concern in that medium Separate total risk factors are calculated for carcinogenic and noncarcinogenic effects The ratio of the risk factor for each chemical to the total risk factor approximates the relative risk for each chemical in the medium

EPA-recommended toxicity factors (reference doses and cancer slope factors) were used in the concentration/toxicity screens (Step 6, Figure 2-1) and in the calculation of risk-based concentrations (Step 9, Figure 2-1) Slope factors and reference doses were determined from IRIS (1993), HEAST (1992 including later supplements) and HEAST (1991) and are listed in Tables 2-3 and 2-4 Chemicals of potential concern that do not have EPA-established toxicity factors are not evaluated quantitatively in the concentration/toxicity screens or in the risk assessment However, their potential contribution to risk is evaluated qualitatively in the risk assessment

Chemicals with very low risk factor ratios compared to other chemicals in the medium were eliminated from further consideration because of their very low potential to contribute to overall risk In this step of the selection process, all chemicals that contribute approximately 1 percent or more of the total risk factor were considered chemicals of concern for evaluation in the quantitative risk assessment This approach greatly reduces the number of chemicals to be carried through a risk assessment However, the approach is conservative (health protective) because it retains some chemicals that contribute as little as 1 percent of the total potential risk In most cases, only a few chemicals contribute the majority of risk from each medium

2.5 EVALUATION OF INFREQUENTLY DETECTED COMPOUNDS

Chemicals detected infrequently (in less than 5 percent of all samples in the medium) can usually be eliminated from consideration as chemicals of concern because of the low potential for exposure However, these compounds were further screened so as not to neglect an infrequently detected compound that could contribute significantly to risk if the compound were detected in a small area along with elevated concentrations of other chemicals of concern In this analysis, maximum measured concentrations were compared to screening levels derived from health RBCs This analysis, summarized below, is presented in detail in Appendix B

For screening purposes, RBCs were defined as chemical concentrations associated with an excess cancer risk of 10^{-6} or a hazard index of 1 0, assuming residential exposures Any low-frequency chemical detected at a concentration greater than 1000 times the respective RBC was identified as representing a potential health threat to exposed receptor populations, and was included in the list of OU-2 "special case" chemicals of concern for evaluation in the risk assessment

RBCs were calculated assuming a residential exposure scenario, using conservative exposure assumptions, and using standard toxicity values (RfDs and SFs) published by EPA RBCs for chemicals in surface and subsurface soils were calculated assuming multiple pathway exposure (ingestion, dermal contact, and inhalation of particulates). RBCs for chemicals in groundwater were calculated based on ingestion only, since this was assumed to be the chief groundwater exposure route The exposure parameters used to calculate RBCs are presented in Appendix B, and are those which were presented in the Exposure Scenarios Technical Memorandum No 9 (EG&G 1993) Toxicity values used to calculate RBCs are listed in Table 2-3

TABLE 2-1
ROCKY FLATS PLANT OU-2
SITE-SPECIFIC CHEMICAL ANALYSIS ROSTER
PHASE II OU-2 SAMPLING PARAMETERS

TOTAL METALS

Target Analyte List

Soil

Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Chromium
Cobalt
Copper
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Vanadium
Zinc

OTHER METALS

Soil

Molybdenum
Strontium
Cesium
Lithium
Tin

OTHER INORGANICS

Soil

pH
Sulfide
Nitrate-Nitrite (as N)
Percent Solids
Cyanide
Moisture Content
Orthophosphate
Bromide
Ammonium
Silica (as Si and SiO2)

INDICATORS

Soil

Dissolved Organic Carbon
Total Organic Carbon

OTHER PARAMETERS

Total Petroleum Hydrocarbons

METALS

Target Analyte List

Groundwater

(Total and Dissolved Metals)

Aluminium
Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Chromium
Cobalt
Copper
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Vanadium
Zinc

OTHER METALS

Groundwater

Molybdenum
Strontium
Cesium
Lithium
Tin

FIELD PARAMETERS

Groundwater

pH
Specific Conductance
Temperature
Dissolved Oxygen

INDICATORS

Groudwater

Total Organic Carbon
Dissolved Organic Carbon
pH

ANIONS

Groundwater

Carbonate
Bicarbonate
Chloride
Sulfate
Nitrate (as N)
Cyanide
Fluoride
Bromide
Silica (as Si and SiO2)
Ammonium
Orthophosphate

OTHER PARAMETERS

Total Petroleum Hydrocarbons

TABLE 2-1
(Continued)

ORGANICS VOLATILES	**ORGANICS PESTICIDES/PCBs**	**TOTAL RADIONUCLIDES**
Target Compound List	**Target Compound List**	<u>Soil</u>
<u>Soil and Groundwater</u>	<u>Soil and Groundwater</u>	Gross Alpha
Chloromethane	alpha-BHC	Gross Beta
Bromomethane	beta-BHC	Uranium-233, 234, 235, and 238
Vinyl Chloride	delta-BHC	Americium-241
Chloroethane	gamma-BHC (Lindane)	Plutonium-239 and 240
Methylbenzene Chloride	Heptachlor	Tritium
Acetone	Aldrin	Strontium-89,90
Carbon Disulfide	Heptchlor Epoxide	Cesium-137
1,1-Dichloroethene	Endosulfan I	Radium-226, 228
1,1-Dichloroethane	Dieldrin	
Total 1,2-Dichlkoroethen	4,4'-DDE	**DISSOLVED RADIONUCLIDES**
Chloroform	Endrin	<u>Groundwater</u>
1,2-Dichloroethane	Endosulfan II	Gross Alpha
2-Butanone	4,4'-DDD	Gross Beta
1,1,1-Trichloroethane	Endosulfan Sulfate	Uranium-233, 234, 235, and 238
Carbon Tetrachloride	4,4'-DDT	Tritium
Vinyl Acetate	Endrin Ketone	Strontium-89, 90
Bromodichloromethane	Methoxychlor	Cesium-137
1,1,2,2-Tetrachloroethane	alpha-Chlordane	Radium-226 and 228
1,2-Dichloropropane	gamma-Chlordane	Tritium
Trans-1,3-Dichloropropene	Toxaphene	
Trichloroethene	Aroclor-1016	**TOTAL RADIONUCLIDES**
Dibromochloromethane	Aroclor-1221	<u>Groundwater</u>
1,1,2-Trichloroethane	Aroclor-1232	Plutonium-239 and 240
Benzene	Aroclor-1242	Americium-241
cis-1,3-Dichloropropene	Aroclor-1248	Tritium
Bromoform	Aroclor-1254	
2-Hexane	Aroclor-1260	
4-Methyl-2-pentanone		
Tetrachloroethene	**SURFACE SOIL PARAMETERS**	
Toluene	Total Organic Carbon	
Chlorobenzene	Carbonate	
Ethyl Benzene	pH	
Styrene	Specific Conductance	
Total Xylenes	Plutonium-239 and 240	
	Americium-241	

TABLE 2-1
(Concluded)

ORGANICS SEMI-VOLATILES **Target Compound List** <u>Soil and Groundwater</u>		
Phenol	Hexachlorobutadiene	N-nitrosodiphenylamine
bis(2-Chloroethyl)ether	4-Chloro-3-methylphenol(para-chloro-	4-Bromophenyl Phenyl Ether
2-Chlorophenol	2-Methylnapthalene	Hexachlorobenzene
1,3-Dichlorobenzene	Hexachlorocylopentadiene	Pentachlorophenol
1,4-Dichlorobenzene	2,4,6-Trichlorophenol	Phenanthrene
Benzyl Alcohol	2,4,5-Trichlorophenol	Anthracene
1,2-Dichlorobenzene	2-Chloronaphthalene	Di-n-butylphthalate
2-Methylphenol	2-Nitroaniline	Fluoranthene
bis(2-Chloroisopropyl)ether	Dimethylphthalate	Pyrene
4-Methylphenol	Acenaphthlene	Butyl Benzylphthalate
N-Nitroso-Dipropylamine	3-Nitroaniline	3,3'-Dichlorobenzidine
Hexachloroethane	Acenaphthene	Benzo(a)anthracene
Nitrobenzene	2,4-Dinitrophenol	bis(2-ethylhexyl)phthalate
Isophorone	4-Nitrophenol	Chrysene
2-Nitrophenol	Dibenzofuran	Di-n-octyl Phthalate
2,4-Dimethylphenol	2,4-Dinitrotoluene	Benzo(b)fluoranthene
Benzoic Acid	2,6-Dinitrotoluene	Benzo(k)fluoranthene
bis(2-Chloroethoxy)methane	Diethylphthalate	Benzo(a)pyrene
2,4-Dichlorophenol	4-Chlorophenyl Phenyl Ether	Indeno(1,2,3-cd)pyrene
1,2,4-Trichlorobenzene	Fluorene	Dibenz(a,h)anthracene
Naphthalene	4-Nitroaniline	Benzo(g,h,i)perylene
4-Chloroaniline	4 6-Dinitro-2-methylphenol	

TABLE 2-2
ROCKY FLATS PLANT OU-2
ANALYTICAL DATA FILE SUMMARY

Data File	Data Description: Borehole		Collected By	Data Used for Chemicals of Concern
BH_IN87A.XLS	Inorganics 1987 (pH, solids cyanide etc)		Weston	All subsurface soil data from above high water table
BH_MT87A.XLS	Metals 1987		Weston	
BH_M91A.XLS	Metals 1991-1992		W-C	
BH_P87A.XLS	Pesticides 1987		Weston	
BH_P91A.XLS	Pesticides 1991 1992		W-C	
B_R87A.XLS	Radionuclides 1987		Weston	
BH_R91A.XLS	Radionuclides 1991-1992		W-C	
BH_S87A.XLS	Semi-volatiles 1987		Weston	
BH_S91A.XLS	Semi volatiles 1991 1992		W-C	
BH_V87A.XLS	Volatile Organics 1987		Weston	
BH_V91A.XLS	Volatile Organics 1991 1992		W-C	
BH_W91A.XLS	Inorganics 1991 1992 (pH, solids, cyanide etc.)		W-C	
Data File	**Data Description. Groundwater**		**Collected By**	**Data Used for Chemicals of Concern**
GWU_P192N.XLS	Pesticides	1st and 2nd Quarters 1992	Site Wide Program (IT)	1st and 2nd Quarter 1992
GW_UP91.XLS	Pesticides	All Quarters 1991	Site Wide Program (IT)	2nd through 4th Quarter 1991
GW_R192D.XLS	Dissolved Radionuclides	1st and 2nd Quarters 1992	Site Wide Program (IT)	1st and 2nd Quarter 1992
GW_R192T.XLS	Total Radionuclides	1st and 2nd Quarters 1992	Site Wide Program (IT)	1st and 2nd Quarter 1992
GW_R792D.XLS	Dissolved Radionuclides	3rd and 4th Quarters 1992	Site Wide Program (IT)	3rd Quarter 1992
GW_R792T.XLS	Total Radionuclides	3rd and 4th Quarters 1992	Site Wide Program (IT)	3rd Quarter 1992
GW_R90D.XLS	Dissolved Radionuclides	All Quarters 1990	Site Wide Program (IT)	Not Used
GW_R90T.XLS	Total Radionuclides	All Quarters 1990	Site Wide Program (IT)	Not Used
GW_R91D.XLS	Dissolved Radionuclides	All Quarters 1991	Site Wide Program (IT)	2nd through 4th Quarter 1991
GW_R91T.XLS	Total Radionuclides	All Quarters 1991	Site Wide Program (IT)	2nd through 4th Quarter 1991
GWU_S192N.XLS	Semi Volatiles	1st and 2nd Quarters 1992	Site Wide Program (IT)	1st and 2nd Quarter 1992
GWU_S91.XLS	Semi Volatiles	4th Quarter 1991	Site Wide Program (IT)	4th Quarter 1991
GWU_V192N.XLS	Volatiles	1st and 2nd Quarters 1992	Site Wide Program (IT)	1st and 2nd Quarter 1992
GWU_V792N.XLS	Volatiles	3rd and 4th Quarters 1992	Site Wide Program (IT)	3rd Quarter 1992
GWU_V90.XLS	Volatiles	All Quarters 1990	Site Wide Program (IT)	Not Used
GWU_V91.XLS	Volatiles	All Quarters 1991	Site Wide Program (IT)	2nd through 4th Quarter 1992
GWU_W192N.XLS	Water Quality Parameters	1st and 2nd Quarters 1992	Site Wide Program (IT)	Not Used
GWU_W792N.XLS	Water Quality Parameters	3rd and 4th Quarters 1992	Site Wide Program (IT)	Not Used
GWU_W90 XLS	Water Quality Parameters	All Quarters 1990	Site Wide Program (IT)	Not Used
GWU_W91.XLS	Water Quality Parameters	All Quarters 1991	Site Wide Program (IT)	Not Used
CHEMS4 CSV	Metals	1st Quarter 1990 4th Quarter 1992	Site Wide Program (IT)	2nd Qtr 1991 3rd Qtr 1992
Data File	**Data Description. Surficial Soil**		**Collected By**	**Data Used for Chemicals of Concern**
SS93FLTR.XLS	1993 data not including background (met, rads, sv pest)		W-C	All
SS_PT.XLS	1991 data (rads)		Stoller	All

TABLE 2-3
TOXICITY FACTORS

Analyte	Oral Slope Factor 1/(mg/kg/day)	Oral RfD (mg/kg/day)	Inhalation Slope Factor 1/(mg/kg/day)	Inhalation RfD (mg/kg/day)	EPA Cancer Weight Evidence
1,1,1,2-tetrachloroethane	2 6E-02 (1)	3 00E-02 (1)	2 60E-02 (1)	-	C
1,1,1-trichloroethane	-	9 00E-02 (2)	-	3 00E-01 (2)	-
1,1,2,2-tetrachloroethane	2 00E-01 (1)	-	2 00E-01 (1)	-	C
1,1,2-trichloroethane	5 70E-02 (1)	4 00E-03 (1)	5 70E-02 (1)	-	C
1,1-dichloroethane	-	1 00E-01 (3)	-	1 40E-01 (2)	C
1,1-dichloroethene	6 00E-01 (1)	9 00E-03 (1)	1 75E-01 (1)	-	C
1,2,3-trichloropropane	-	6 00E-03 (1)	-	-	-
1,2,4-trichlorobenzene	-	1 00E-02 (1)	-	3 00E-03 (2)	-
1,2-dibromo-3-chloropropane	1 40E+00 (2)	-	2 40E-03 (2)	5 00E-05 (1)	B2
1,2-dibromoethane	8 50E+01 (1)	-	7 60E-01 (2)	-	B2
1,2-dichlorobenzene	-	9 00E-02 (1)	-	4 00E-02 (2)	-
1,2-dichloroethane	9 10E-02 (1)	-	9 10E-02 (1)	-	B2
1,2-dichloroethene	-	9 00E-03 (2)	-	-	-
1,2-dichloropropane	-	-	-	1 00E-03 (1)	-
1,2-dimethylbenzene (o-xylene)	-	2 00E+0 (1)	-	-	-
1,3-dimethylbenzene (m-xylene)	-	2 00E+0 (1)	-	-	-
1,4-dichlorobenzene	2 40E-02 (2)	-	-	2 00E-1 (2)	C
2-butanone	-	6 0E-01 (1)	-	3 0E-01 (1)	-
4,4'-DDT	3 40E-01 (1)	5 00E-04 (1)	3 40E-01 (1)	-	B2
4-methyl-2-pentanone	-	5 00E-02 (2)	-	2 00E-02 (2)	-
acenapthene	-	6 00E-02 (1)	-	-	-
acetone	-	1 00E-01 (1)	-	-	-
anthracene	-	3 00E-01 (1)	-	-	-
antimony	-	4 00E-04 (1)	-	-	-
Aroclor-1254	7 70E+00 (1)	-	-	-	B2
arsenic	1 75E+00 (1)	3 00E-04 (1)	1 50E+01 (1)	-	A
barium	-	7 00E-02 (1)	-	1 40E-04 (2)	-
benzene	2 90E-02 (1)	-	2 90E-02 (2)	-	A
benzo(a)anthracene	5 80E-01 (4)	-	-	-	B2
benzo(a)pyrene	5 80E+00 (4)	-	6 10E+00 (2)	-	B2
benzo(b)fluoranthene	5 80E-01 (4)	-	-	-	B2
benzo(k)fluoranthene	5 80E-01 (4)	-	-	-	B2
benzoic acid	-	4 00E+00 (1)	-	-	-
beryllium		5E-1 (2)	8 4E-10 (1)		B2
bis(2-ethylhexyl)phthalate	1 40E-02 (1)	2 00E-02 (1)	-	-	B2
bromodichloromethane	6 20E-02 (1)	2 00E-02 (1)	-	-	B2
bromoform	7 90E-03 (1)	2 00E-02 (1)	3 90E-03 (2)	-	B2
butyl benzylphthalate	-	2 00E-01 (1)	-	-	-
cadmium (food)	-	1 0E-03 (1)	6 30E+00 (1)	-	B1

TABLE 2-3
TOXICITY FACTORS

Analyte	Oral Slope Factor 1/(mg/kg/day)	Oral RfD (mg/kg/day)	Inhalation Slope Factor 1/(mg/kg/day)	Inhalation RfD (mg/kg/day)	EPA Cancer Weight Evidence
cadmium (water)	-	5 00E-04 (1)	6 30E+00 (1)	-	B1
carbon tetrachloride	1 30E-01(1)	7 00E-04 (1)	5 25E-02 (1)	-	B2
chlorobenzene	-	2 00E-02 (1)	-	5 00E-03 (3)	-
chloroethane	-	-	-	3 00E+00 (1)	-
chloroform	6 10E-03 (1)	1 00E-02 (1)	8 00E-02 (1)	-	B2
chloromethane	1 30E-02 (2)	-	6 30E-03 (2)	-	C
chromium III	-	1 00E+00 (1)	-	-	-
chrysene	5 80E-02 (4)	-	-	-	B2
cis-1,2-dichloroethene	-	1 00E-02 (2)	-	-	-
cis-1,3-dichloropropene	-	3 00E-04 (1)*	-	5 00E-03 (1)*	B2
cumene	-	4 00E-02 (1)	-	3 00E-03 (2)	-
cyanide	-	2 00E-02 (1)	-	-	-
di-n-butylphthalate	-	1 00E+01 (1)	-	-	-
di-n-octylphthalate	-	2 00E-02 (2)	-	-	-
dibromomethane	-	1 00E-02 (3)	-	-	-
dichlorodifluoromethane	-	2 00E-01 (1)	-	5 00E-02 (3)	-
diethyl phthalate	-	8 00E-01 (1)	-	-	-
ethylbenzene	-	1 00E-01 (1)	-	3 00E-01 (1)	-
fluoranthene	-	4 00E-02 (1)	-	-	-
fluorene	-	4 00E-02 (1)	-	-	-
heptachlor epoxide	9 10E+00 (1)	1 30E-05 (1)	9 10E+00 (1)	-	B2
hexachlorobutadiene	7 80E-02 (1)	-	7 80E-02 (2)	-	C
hexachloroethane	1 40E-02 (1)	1 00E-03 (1)	1 40E-02 (1)		C
indeno(1,2,3-cd)pyrene	5 80E-01 (4)	-	-	-	B2
manganese	-	1 00E-01 (3)	-	1 10E-04 (1)	-
mercury	-	3 00E-04 (2)	-	9 0E-05 (2)	-
methylene chloride	7 50E-03 (1)	6 00E-02 (1)	1 60E-03 (1)	9 0E-01 (2)	B2
molybdenum	-	5 00E-03 (1)	-	-	-
N-nitrosodiphenylamine	4 90E-03 (1)	-	-	-	B2
naphthalene	-	4 00E-02 (2)	-	-	-
nickel		2 00E-2 (2)			
o-chlorotoluene	-	2 00E-02 (1)	-	-	-
p-xylene	-	2 00E+00 (1)	-	-	-
pentachlorophenol	1 20E-01(1)	3 00E-02 (1)	-	-	B2
pyrene	-	3 00E-02 (1)	-	-	-
selenium		5 00E-3 (2)			
silver	-	5 00E-03 (1)	-	-	-
strontium		8 8E-1 (2)			
styrene	-	2 00E-01 (1)	-	3 00E-01 (1)	-
tetrachloroethene	5 10E-02 (3)	1 00E-02 (1)	1 80E-03 (3)	-	B2
thallium	-	7 00E-05 (2)	-	-	-
tin		6 00E-02 (2)			
toluene	-	2 00E-01 (1)	-	1 10E-01 (1)	-

TABLE 2-3
TOXICITY FACTORS

Analyte	Oral Slope Factor 1/(mg/kg/day)	Oral RfD (mg/kg/day)	Inhalation Slope Factor 1/(mg/kg/day)	Inhalation RfD (mg/kg/day)	EPA Cancer Weight Evidence
trans-1,2-dichloroethene	-	2 00E-02 (1)	-	-	-
trichloroethene	1 10E-02 (3)	-	5 95E-03 (3)	-	B2
vinyl chloride	1 90E+0 (1)	-	3 00E-01 (1)	-	A
zinc	-	2 00E-01(2)	-	-	-

Sources
1 = IRIS
2 = HEAST 1992 (including supplements)
3 = HEAST 1991
4 = EPA Region IV Guidance, February 1992
* Values are for 1,3-dichloropropene No data for individual isomer
A = Human carcinogen
B1 = Probable human carcinogen (limited human data)
B2 = Probable human carcinogen (animal data only)
C = Possible human carcinogen
- = Not classifiable or not carcionogenic

TABLE 2-4
TOXICITY FACTORS
FOR RADIONUCLIDES

Analyte	Oral Slope Factor (Risk/pCi)	Inhalation Slope Factor (Risk/pCi)	External Slope Factor (Risk/yr/pCi/g)	EPA Cancer Weight of Evidence
241 Americium	2 4E-10	3 2E-08	4 9E -09	A
134 Cesium	4 1E-11	2 8E-11	5 2E-06	A
137 Cesium	2 8E-11	1 9E-11	0 0E+00	A
238 Plutonium	2 2E-10	3 9E-08	2 8E-11	A
238 Plutonium	2 3E-10	3 8E-08	1 7E-11	A
240 Plutonium	2 3E-10	3 8E-08	2 7E-11	A
226 Radium	1 2E-10	3 0E-09	1 2E-08	A
228 Radium	1 0E-10	6 6E-10	0 0E+00	A
Strontium 89	3 0E-12	2 9E-12	4 7E-10	A
Strontium 90	3 3E-11	5 6E-11	0 0E+00	A
Tritium	5 4E-14	7 8E-14	0 0E+00	A
Uranium 233,234 *	1 6E-11	2 6E-08	3 0E-11	A
Uranium 235	1 6E-11	2 5E-08	2 4E-07	A
Uranium 238	1 6E-11	2 40E-08	2 10E-11	A

Source HEAST 1992

A = Class A (human) carcinogen
* = Slope factors shown are for u-234

3.0
GROUNDWATER CHEMICALS OF CONCERN

3.1 DATA EVALUATION

Chemicals of concern in groundwater were selected using the data sets identified in Table 2-2 Samples collected in 2nd through 4th quarter 1991 and 1st through 3rd quarter 1992 were used to evaluate volatile organic compounds, pesticides and PCBs, metals, and radionuclides Samples collected in 4th quarter 1992 and 1st quarter and 2nd quarters 1992 were used to evaluate semivolatile organic compounds (semivolatile data were not available prior to 4th quarter 1991, no 3rd quarter 1992 data were received for semivolatiles)

The data received from RFEDs were reviewed and edited using the steps and criteria outlined in Section 2 1 to develop a data set of environmental samples for further evaluation Groundwater data were then divided into two sets for selection of preliminary chemicals of concern (1) analytical results from wells screened in the No 1 Sandstone and (2) analytical results from all (UHSU) wells (i e., wells in the No 1 Sandstone, alluvium, colluvium, and valley fill) The No 1 Sandstone could support a drinking water well, under a hypothetical future residential development scenario, future residents could be exposed to OU-2 contaminants through ingestion of water from the No 1 Sandstone Therefore, analytical results from the No 1 Sandstone are used to select chemicals of concern for the residential groundwater ingestion scenario

The alluvium, colluvium, and valley fill are relatively thin, discontinuous, and on slopes (colluvium), have low yields, and are only intermittently saturated (see Appendix C) These units cannot provide drinking water and were therefore not included as exposure media for on-site residential groundwater ingestion exposures However, analytical results from samples collected from monitoring wells in the alluvium, colluvium, valley fill, and No 1 Sandstone were used to evaluate contaminant migration through groundwater to surface water in Woman Creek and Walnut Creek These units are referred to collectively as the UHSU

3.2 BACKGROUND COMPARISON FOR INORGANIC COMPOUNDS

The comparison of OU-2 data for metals and radionuclides detected in groundwater to background data is presented in Appendix A Metals and radionuclides with 5 percent or more of data above the 95% UTL of background or that were estimated to exceed background levels by the ANOVA evaluation were retained for further evaluation as potential chemicals of concern Total metals and radionuclides above background levels were considered potential chemicals of concern for purposes of evaluating groundwater ingestion scenario (No 1 Sandstone) Dissolved metals and radionuclides above background level were considered potential chemicals of concern for migration of contaminants in groundwater Metals and radionuclides that did not exceed background levels or that were evidently unrelated to operations or sources in OU-2 based on spatial and temporal evaluation of the data were eliminated from further consideration as potential chemicals of concern

Tables 3-1 through 3-4 summarize the results of comparing concentrations of metals and radionuclides in groundwater to background levels Tables 3-1 and 3-2 show the results for total metals and radionuclides in the No 1 Sandstone Tables 3-3 and 3-4 show the results for dissolved metals and radionuclides in the UHSU Total inorganics in the No 1 Sandstone are evaluated as chemicals of concern for risk due to on-site groundwater ingestion, and dissolved inorganics are evaluated in the UHSU for migration of contaminants in groundwater Metals and radionuclides that exceeded background and that were identified as potential OU-2 contaminants based on data evaluation were included in concentration/toxicity screens to select chemicals of concern for use in risk assessment.

Metals are eliminated from further consideration if less than 5 percent of the OU-2 data exceeded the 95% UTL of background and if the ANOVA analysis showed no significant difference from background ($p \leq 0.05$) Metals that appear to exceed background by one or both of the tests are retained for inclusion in a concentration/toxicity screen, or for further evaluation of the spatial and temporal distribution and occurrence of elevated concentrations to identify potential OU-2 contaminants This was done in order to eliminate analytes from further consideration that are not actual site contaminants It is important that risk assessment and the selection of remedies be focussed on actual site contaminants that could threaten public health or the environment rather than on naturally occurring elements or trace contaminants that may be detected infrequently at elevated concentrations but are not characteristic of site contamination

3.2 1 No. 1 Sandstone

Table 3-1 shows the results of the background comparison for total metals in No 1 Sandstone On the basis of the statistical tests, the following metals do not appear to exceed background levels arsenic, antimony, arsenic, beryllium, cadmium, chromium, cobalt, copper, lithium, molybdenum, nickel, silver, vanadium, and zinc On the basis of spatial and temporal evaluation, the following inorganic compounds are not considered site-related contaminants in the No 1 Sandstone cesium, cyanide, lead, mercury, selenium, strontium, thallium, and tin The reasons are discussed below Other inorganics in the No 1 Sandstone with widespread elevated concentrations that are potentially related to contaminant plumes in OU-2 are aluminum, barium, manganese, and zinc These metals are widely distributed and consistently found at elevated concentrations at known source areas

Metals Eliminated as Contaminants on the Basis of Spatial/Temporal Evaluation No. 1 Sandstone

Cesium Reported concentrations for total cesium range from 30 to 80 µg/L (all estimated below sample reporting limit) The detection frequency in the No 1 Sandstone is 9 percent (6 of 67 samples), which is relatively low The background UTL is 408 µg/L Typical detection limits are 500 or 1000 µg/L, which probably explains the results of the ANOVA and UTL comparisons The highest concentrations detected (50 to 80 µg/L) were found in three wells 2991, 3091, and 3691 screened at the base of the No 1 Sandstone in the NE Trench Area Well pairs screened in the upper part of the No. 1 Sandstone (but below the bottom of the nearby trenches) were nondetect for cesium at reporting limits of 500 and 1000 µg/L Cesium is probably not present in these samples, regardless of the high detection limits, because in other samples, cesium was positively identified at concentrations one or two orders of magnitude lower than detection limits The non-detects in the upper No 1 Sandstone suggests that cesium is not being transported from source areas in the trenches At wells 2591 and 10991, which are unrelated to source areas and screened in the No 1 Sandstone, cesium was also detected at estimated concentrations of 30 to 70 µg/L Therefore, cesium is eliminated as a site-related chemical of potential concern in the No 1 Sandstone, since most of the estimated elevated concentrations are not related to source areas, frequency of detection is low and there is no temporal pattern to the occurrences of elevated concentrations

Cyanide Cyanide concentrations exceeded the background UTL of 5 µg/l (background maximum = 8 5 µg/L) in three unrelated locations well 1491 (8 5 µg/L), well 3687 (12 5 µg/L) and well 13191 (20 7 µg/L) The rare and scattered occurrences of concentrations somewhat above background range indicate that elevated cyanide is not characteristic of groundwater in the No 1 Sandstone and that it is not a chemical of concern for OU-2

Lead Elevated concentrations of total lead up to 171 µg/L) were detected in several wells screened in the No 1 Sandstone in the NE Trenches Area, in the Mound Area, and west of the

903 Pad However, most of these wells also contained elevated concentrations of total iron, aluminum, and lithium, which are rock-forming elements Dissolved concentrations of these elements were not elevated, and there is no evidence of dissolved-phase plume For example, at two wells with elevated total lead concentrations (well 11891 at 171 µg/L and in well 3691 at 86 µg/L), dissolved lead was non-detect at a reporting limit of 3 µg/L The elevated total lead concentrations may be related to suspended solids in the water samples rather than to leaching due to OU-2 contamination because there is no evidence of a dissolved-phase plume

Mercury Mercury was detected in 16 percent of the samples analyzed The maximum concentration in the No 1 Sandstone (0 8 µg/L) was detected in well 5691 in the NE Trench Area The background UTL is 0 2 µg/L Mercury was also detected in three wells (2387, 1791, and 1491) in the Mound Area, in concentrations ranging from 0 27 to 0 62 µg/L, these wells are screened in the No 1 Sandstone However, the upper paired wells were non-detect for mercury at a reporting limit of 0 2 µg/L Dissolved-phase mercury was not elevated above background levels, and there is no evidence of a contaminant plume Mercury is not considered a contaminant in groundwater because (1) even the elevated concentrations are low (0 25 to 1 2 µg/L), (2) dissolved-phase concentrations are within background levels, (3) elevated concentrations occur in some wells screened at the base of the No 1 Sandstone but not in paired wells screened near the top of the sandstone, and (4) only one well (11691 in the NE Trench Area) had mercury detected in more than one sampling event

Selenium Selenium was not detected in concentrations above 5 µg/L, the background UTL, in No 1 Sandstone wells near source areas It was detected in two wells at Indiana Avenue (twice in well 286 at approximately 11 µg/L and twice in well 41591 at approximately 8 µg/L) Because elevated concentrations were found distant from source areas, but not close to source areas, selenium is not considered a contaminant in the No 1 Sandstone

Strontium Concentrations for total strontium were somewhat elevated in 4 of approximately 80 samples collected from wells screened in the No 1 Sandstone Elevated concentrations from 1010 to 1370 µg/L (background UTL = 1100 µg/L) Comparable concentrations also occur in wells that are unrelated to source areas (such as wells 286 and 41591, both at Indiana Avenue) Strontium was also detected at somewhat elevated concentrations in some wells potentially related to source areas These latter wells include well 1491 at the 903 (Pad 1040 µg/L), and well 291 near the inner East Gate (1070 µg/L) The filtered fraction was also elevated in most samples where total strontium was elevated Since concentrations are found in wells unrelated to source areas at concentrations comparable to those found near source areas, since elevated concentrations are only somewhat above background, and since there is no evidence of a total or dissolved-phase plume, strontium is not considered a contaminant for OU-2

Thallium Thallium was detected in 15 percent of the samples analyzed in concentrations ranging from 1 to 3 µg/L (total thallium), background UTL is 2 µg/L Thallium is not considered a contaminant in the No 1 Sandstone because of the low frequency of detection of elevated concentrations (5% of the detected thallium results exceed the background UTL), and because the elevated concentrations are not significant

Tin No detected concentrations for total tin exceeded 92 µg/L (the background UTL) There is not apparent relationship with source areas or a phone, therefore, tin is not considered a contaminant in the No 1 Sandstone

Table 3-2 summarizes the background comparison for total radionuclides in the No 1 Sandstone Radionuclides considered to be potential OU-2 contaminants in the No 1 Sandstone are americium 241 (0 04 pCi/L), and plutonium 239/240 (0 01 pCi/L) Total (as opposed to dissolved) uranium isotopes were only analyzed for in 4 groundwater samples collected in the Mound Area Uranium is naturally occurring, and according to the statistical tests the detected concentrations are within background range Dissolved concentrations also did not exceed background according to the statistical tests (see Appendix D) Because uranium isotopes could be related to sources in OU-2 based on plant history, further evaluation of a larger data set, including dissolved concentrations in the No 1 Sandstone, borehole (subsurface soil) data, and isotope ratios is recommended before identifying uranium isotopes as chemicals of concern in groundwater

3.2.2 UHSU

Table 3-3 shows the results of the background comparison for dissolved metals in the UHSU, including the No 1 Sandstone Dissolved phase constituents are evaluated in the UHSU rather than total because dissolved-phase contaminants may be transported in groundwater to exposure points in Woman or Walnut Creeks

On the basis of the statistical tests, the following metals do not appear to exceed background levels aluminum, cadmium, cobalt, lead, lithium, mercury, silver, and vanadium On the basis of spatial and temporal evaluation, the following metals are not considered site-related contaminants in the UHSU antimony, arsenic, beryllium, chromium, molybdenum, nickel, selenium, strontium, thallium, and tin The reasons are discussed below Other metals in

UHSU groundwater with widespread elevated concentrations that are potentially related to contaminant plumes in OU-2 are barium, cesium, manganese, and zinc

Antimony Antimony concentrations are evenly distributed unrelated to source areas Concentrations range from 8 to 88 µg/L, the maximum value was detected at well 286 at Indiana Street Other detected values were below the 95% UTL of background (53 µg/L) and appear to have no relationship to source areas

Arsenic Detected concentrations of arsenic range from 1 to 8 µg/L Two elevated concentrations (6 3 and 7 6 µg/L) were observed in samples from alluvial wells near the 903 pad, but other concentrations ranged from 1 to 3 µg/L The background UTL is 8 µg/L Elevated arsenic is not characteristic of groundwater contamination in OU-2 and it is therefore eliminated as a chemical of concern

Beryllium Beryllium was detected in only 4 percent of the samples The OU-2 mean concentration is 2 µg/L (maximum is 3 µg/L), background mean is 1 µg/L This difference in mean concentrations is not considered important because the concentrations are uniformly low and the frequency of detection is low. Beryllium is not considered an OU-2 contaminant in groundwater

Chromium Eight results out of 194 exceed the background UTL of 13 µg/L, however, the OU-2 maximum detected value of 23 µg/L is equivalent to the background maximum, and the background mean (6 µg/L) is greater than the OU-2 mean (5 µg/L) Three samples with elevated concentrations (16 to 23 µg/L) were from wells associated with in the NE Trench Area (wells 3686 and 3687), but other elevated observations are not consistently associated with source areas Therefore, chromium is not retained as a potential chemical of concern in OU-2

Molybdenum Only one sample result of 67 µg/L (at well 2987) exceeded the background UTL of 64 µg/L. Other detected concentrations ranged from approximately 5 to 25 µg/L, with somewhat higher concentrations (20 to 67 µg/L) seen at wells 5091 and 2987 Elevated concentrations are highly localized and no other meaningful spatial or temporal distribution is apparent Because all but one sample result were below the background UTL, molybdenum is not considered a site-related contaminant in OU-2

Nickel Seven sample results exceeded the background UTL of 30 µg/L Elevated concentrations of nickel were detected in four samples from well 2987 (239 to 1210 µg/L), one sample each from well 3686 (287 µg/L) and well 6586 (65 µg/L), and in one sample from well

286 at Indiana Street (46 µg/L) The elevated concentrations do not appear to be associated with source areas in OU-2 or with a contaminant plume Other detected values ranged from 2 to 30 µg/L, which are equal to or below the background UTL of 30 µg/L Because elevated concentrations are highly localized to three wells within OU-2 (not counting well 286 at Indiana Street), all of which are screened in the colluvium or valley fill, and do not appear to be associated with source areas, nickel is not considered an OU-2 related contaminant

<u>Selenium</u> Selenium concentrations are not elevated above background UTL of 5 µg/L except at well 2987 (123 to 168 µg/L in four samples) and at wells 286 and 41591 at Indiana Street, where selenium was detected at concentrations of 9 and 12 µg/L Well 2987 has consistently elevated concentrations of metals, but these metals concentrations are not considered indicative of contamination in OU-2 Therefore, selenium is not considered a contaminant in OU-2

<u>Strontium</u> The background UTL concentration for strontium is 1041 µg/L (maximum = 1710 µg/L) Very few samples collected in OU-2 had results exceeding these levels Strontium was detected at 1170 µg/L at well 1391 in the Mound Area (background UTL = 1041 µg/L) Strontium was also detected in elevated concentrations (1590 to 1910 µg/L) in four samples from well 2987, in samples collected from wells 286 and 41591 at Indiana Street (2000 to 2290 µg/L), in well 7391 near a source trench (about 3000 µg/L in two samples), and in well 3686 (2020 µg/L), which is screened in the valley fill in Walnut Creek Strontium is otherwise evenly distributed throughout OU-2 in concentrations of less than 1000 µg/L Because strontium was detected in comparable concentrations in wells near source areas and at locations distant from source areas, it is not considered an OU-2 contaminant

<u>Thallium</u> Thallium was only detected in 6 percent of the samples, in concentrations ranging from 1 to 2 µg/L (Background mean is 3 µg/L) It was not detected in 94 percent of the samples at a detection limit of 10 µg/L It is not considered a contaminant

<u>Tin</u> Tin was detected in 10 percent of the samples from the UHSU The maximum concentration of tin was 89 µg/L, detected in well 1787 in the Mound Area, compared to the background UTL of 76 µg/L It was otherwise sporadically detected at concentrations ranging from 15 to 52 µg/L, the latter result being from well 286 at Indiana Street Tin is not considered an OU-2 contaminant because only one detection exceeded the background UTL and because the next highest detection was at well 286 at Indiana Street, which is unrelated to source areas in OU-2

Table 3-4 summarizes the background comparison for dissolved radionuclides in the UHSU For a number of the analytes, few background data were available for comparison Therefore all are retained for further evaluation in a concentration/toxicity screen and spatial and temporal analysis Further evaluation is especially important for the uranium isotopes, which could be naturally occurring or related to sources in OU-2 Although the statistical procedures indicate that the uranium isotopes do not exceed background levels, they have been included in the concentration/toxicity screens to help identify those isotopes on which to focus further spatial and temporal analysis

3.3 FREQUENCY OF DETECTION

Organic compounds detected at a frequency of 5 percent or greater were considered potential chemicals of concern These compounds are listed in Tables 3-5 (No 1 Sandstone) and 3-6 (UHSU) and are included in the concentration/toxicity screens that accompany this section Frequency of detection was evaluated separately for the No 1 Sandstone and UHSU for consistency with the evaluation of metals and radionuclides

Infrequently detected compounds (detected at less than 5 percent frequency) are listed in Tables 3-7 and 3-8 Concentrations of infrequently detected organic compounds were further evaluated as described in Section 3 5 to identify "special case" chemicals of concern for evaluation in the risk assessment

3 4 CONCENTRATION/TOXICITY SCREENS

Concentration/toxicity screens were used to identify chemicals to be evaluated in the quantitative human health risk assessment The screening process permits selecting chemicals, based on concentration and toxicity, that could contribute significantly to risk and identities chemicals that can be eliminated from further consideration because they contribute insignificantly to overall risk The screen was performed for all inorganic constituents detected above background levels and for all organic compounds detected at a frequency of 5 percent or greater The concentration/toxicity screen process was explained in Section 2 4 In performing the concentration/toxicity screens for organic compounds detected in groundwater, if both inhalation and oral toxicity factors were available for organic compounds, the toxicity value that resulted in the highest relative risk value was used For evaluation of metals and radionuclides in groundwater, only oral toxicity factors were used

Results of the screen for the No 1 Sandstone are shown in Tables 3-9 (Noncarcinogenic Effects), 3-10 (Carcinogenic Effects), and 3-11 (Radionuclides) Results of the screen for the UHSU are shown in Tables 3-12 (Noncarcinogenic Effects), 3-13 (Carcinogenic Effects), and 3-14 (Radionuclides)

With a few exceptions, the chemicals of concern identified by the concentration/toxicity screens are the same for both the No 1 Sandstone alone and the UHSU as a whole carbon tetrachloride, trichloroethane, tetrachloroethene, 1,1-dichloroethene, chloroform, manganese, and americium-241 The exceptions are that cis-1,2-dichloroethene and uranium 235 are identified as additional chemicals of concern in the UHSU but not in the No 1 Sandstone alone, and manganese, barium, methylene chloride, and plutonium 239/240 are identified as additional chemicals of concern in the No 1 Sandstone The main reasons for the differences are (1) the higher concentration of carbon tetrachloride in the UHSU, which comprises a larger fraction of the total risk factor and excludes constituents such as, manganese and methylene chloride and (2) the inclusion of the uranium isotopes in the concentration/toxicity screen for the UHSU even though it is equivocal whether they exceed background or not Their inclusion results in the exclusion of other radioisotopes such as, plutonium 239, 240, which constitutes an insignificant fraction of overall risk compared to the uranium isotopes (see Table 3-14) It is recommended that the distribution of the uranium isotopes be evaluated further to asses whether they are likely to be related to OU-2 waste sources or not so that only site-related compounds are identified as chemicals of concern for risk assessment

A note on methylene chloride although methylene chloride is a common laboratory contaminant, it was consistently detected in elevated concentrations near solvent sources areas and was therefore retained as a potential site-related chemical of concern for evaluation in the concentration/toxicity screens

3.5 EVALUATION OF INFREQUENTLY DETECTED COMPOUNDS

As stated in Section 3.2, compounds detected at less than 5 percent frequency can usually be eliminated from further consideration because the potential for exposure is low However, these compounds were further screened so as not to neglect infrequently detected compounds that could contribute significantly to risk if the chemicals were detected in association with other potentially hazardous compounds at source areas or at locations where exposures could occur In this screen, maximum concentrations of infrequently detected compounds were compared to risk-based screening values using the approach outlined in Section 2 5 and described in greater detail in Appendix B Complete results of the evaluation are shown in Table B-6 The evaluations shows that the following two infrequently detected compounds have maximum concentrations that exceed the screening values used in the analysis

1,2-dibromoethane
vinyl chloride

The compound 1,2-dibromoethane was detected in 2 of 170 groundwater samples at concentrations of 1 8 µg/L (well 6691 in the 903 Pad) and at 13 µg/L (well 7391, IHSS 109) Well 6691 is screened in the Rocky Flats alluvium, and well 7391 is screened in the colluvium Both wells are in or near contaminant source areas where other solvents have been detected The samples with positive results were collected in May 1992 These wells were also sampled in November 1992 (4th quarter) and 1,2-dibromoethane was not detected, although reporting limits were elevated, so the results are inconclusive 1,2-dibromoethane is not characteristic of groundwater contamination at OU-2 because it is so infrequently detected However, it will be evaluated in the risk assessment as a "special-case" chemical of concern

Vinyl chloride was detected at approximately 4 percent frequency of detection (10 samples out of about 280) The highest concentrations (380 to 860 µg/L) were detected in several samples collected at well 3586 This well is located at the northern boundary of OU-2 near the discharge from the Protected Area and near a seep that is being investigated under a separate program Vinyl chloride was not detected in OU-2 upgradient of this well Therefore, vinyl chloride detected in this well is probably not related to source areas in OU-2 Vinyl chloride was detected in much lower concentrations (2 to 3 µg/L) in samples from well 7391, where it is co-located with other solvents Vinyl chloride is included as a "special-case" chemical of concern for OU-2

3.6 SUMMARY OF CHEMICALS OF CONCERN IN GROUNDWATER

Summary lists of chemicals of concern identified by the concentration/toxicity screens are shown in Tables 3-15 (No 1 Sandstone) and 3-16 (UHSU)

TABLE 3-1
ROCKY FLATS PLANT OU-2
SUMMARY OF BACKGROUND COMPARISON
TOTAL METALS IN GROUNDWATER, µg/L
NO 1 SANDSTONE

Analyte	DF % (1)	% Data > 95% UTL (1)	ANOVA p (2)		Potential Contaminant? No (3)	Potential Contaminant? Yes (4)	Spatial /Temporal / Other (See Text)	OU-2 Contaminant?
Aluminum	100	71	<0 01			X	Elevated concentrations in many wells near source areas	Yes
Antimony	20	0	0 01	*	X			No
Arsenic	77	4	0 6		X			No
Barium	100	7	<0 01			X	Elevated concentration in many wells near source areas	Yes
Beryllium	63	0	<0 01	*	X			No
Cadmium	36	0	<0 01	*	X			No
Cesium	9	24	<0 01			X	Relatively low concentrations unrelated to source areas	No
Chromium	75	0	0 1	*	X			No
Cobalt	68	0	<0 01	*	X			No
Copper	83	0	0 03	*	X			No
Cyanide	44	21	<0 01			X	Erratic hits, low frequency, no spatial significance	No
Lead	99	53	<0 01			X	Widely distributed, low dissolved conc , no dissolved plume	No
Lithium	93	0	0 02	*	X			No
Manganese	100	31	<0 01			X	Elevated concentrations in many wells near source areas	Yes
Mercury	15	15	<0 01			?	Erratic hits, low frequency, no dissolved plume	No
Molybdenum	49	0	0 01	*	X			No
Nickel	85	0	0 05	*	X			No
Selenium	50	18	0 3			?	Relatively low concentrations unrelated to source areas	No
Silver	13	0	0 03	*	X			No
Strontium	99	25	<0 01			X	Elevated concentrations found far from source areas	No
Thallium	15	5	<0 01			?	Max concentrations (3ug/L) is not much above background (2ug/L)	No
Tin	21	1	<0 01			?	Maximum concentrations (87 ug/L) < background UTL	No
Vanadium	100	0	<0 01	*	X			No
Zinc	98	0	0 04	*	X			No

(1) Detection frequency and UTL comparison from Table A-1
(2) Table A-9 p < 0 05 is considered significant
(3) <5% data > 95% UTL and p > 0 05
(4) > 5% data > 95% UTL and p < 0 05
? Either > 5% data > 95% UTL or p < 0 05

* Background mean exceeds OU-2 mean

TABLE 3-2
ROCKY FLATS PLANT OU-2
SUMMARY OF BACKGROUND COMPARISON
TOTAL RADIONUCLIDES IN GROUNDWATER, pCi/L
NO 1 SANDSTONE

Analyte	DF (1)	% Data > 95% UTL (1)	ANOVA p (2)	Potential Contaminant? No (3)	Potential Contaminant? Yes (4)	Spatial/Temporal/Other (see text)	OU-2 Contaminant?
Americium 241	86/102	7	0 2		?	Probable contaminant	Yes
Cesium 137	49/109	0	<0 01*	X			No
Plutonium 239,240	100/106	20	0 82		?	Probable contaminant	Yes
Strontium 89,90	1/4		-		?	Excluded based on insufficient data	No
Uranium 233,234	4/4	0	0 5	X		Total Ur isotopes were sampled for in the Mound Area	
Uranium 235	4/4	0	0 02 *	X		They may be retained as "special case" chemicals of concern pending	
Uranium 238	4/4	0	0 26	X		further evaluation of whether they are OU-2 related contaminants	

(1) Detection frequency (no detects/no samples) and UTL comparison from Table A-2
(2) Table A-10 p < 0 05 is considered significant
(3) <5% data > 95% UTL and p > 0 05
(4) > 5% data > 95% UTL and p < 0 05
? Either >5% data >95% UTL or p < 0 05
* Background mean exceeds OU2 mean

TABLE 3-3
ROCKY FLATS PLANT OU-2
SUMMARY OF BACKGROUND COMPARISON
DISSOLVED METALS IN GROUNDWATER, µg/L
UHSU

Analyte	DF % (1)	% Data > 95% UTL (1)	ANOVA p (2)	Potential Contaminant? No (3)	Potential Contaminant? Yes (4)	Spatial/Temporal/Other (see text)	OU-2 Contaminant?
Aluminum	74	1	0 20 *	X			No
Antimony	17	6	<0 01		X	Evenly distributed, unrelated to source areas	No
Arsenic	11	0	<0 01		?	Two results > background, max conc = 8 ug/L	No
Barium	100	37	<0 01		X		Yes
Beryllium	4	0	<0 01		?	4% detection frequency; max conc = 3 ug/L	No
Cadmium	11	1	0 21	X			No
Cesium	20	0	<0 01		?	Relatively low concentrations, but possibly related to source areas	Yes
Chromium	24	8	0 19 *		?	Some elevated concentrations related to source areas, but not consistent, background mean > OU-2 mean	No
Cobalt	6	0	<0 01	X			No
Copper	25	0	<0 01		?		No
Lead	6	1	<0 01 *	X			No
Lithium	79	1	<0 01 *	X			No
Manganese	73	46	<0 01		X		Yes
Mercury	3	0	<0 01 *	X			No
Molybdenum	45	1	<0 01		?	One result > background UTL, no relation to source area	No
Nickel	31	6	<0 01		?	Some elevated concentrations related to source areas but not consistent	No
Selenium	36	5	0 01		?	High concentrations only at some wells	No
Silver	9	1	0 07 *	X			No
Strontium	99	6	<0 01		X	Elevated concentrations at source areas and non-source areas	No
Thallium	6	0	<0 01		?	Concentrations do not exceed background	No
Tin	10	2	<0 01		?	One result > background UTL, one elev conc at fenceline	No
Vanadium	69	0	0 26 *	X			No
Zinc	67	4	0 41		?		Yes

(1) Detection frequency and UTL comparison from Table A-3
(2) Table A-11 p < 0 05 is considered significant
(3) <5% data > 95% UTL and p > 0 05
(4) > 5% data > 95% UTL and p < 0 05

? Either >5% data > 95% UTL or p <0 05
* Background mean exceeds OU-2 mean

TABLE 3-4
ROCKY FLATS PLANT OU-2
SUMMARY OF BACKGROUND COMPARISON
DISSOLVED RADIONUCLIDES IN GROUNDWATER, pCi/L
UHSU

Analyte	DF (1)	% Data > 95% UTL (1)	ANOVA p (2)	Potential Contam? No (3)	Potential Contam? Yes (4)	Spatial/Temporal/Other (see text)	OU-2 Contam-inant?
Americium 241	10/10	-	-		?	Probable contaminant	Yes
Cesium 137	9/29	-	-	X			
Plutonium 239,240	10/13	-	-		?	Probable contaminant	Yes
Radium 226	53/54	9	0 02		X		Yes
Strontium 89,90	167/198	-	-		?		Yes
Tritium	183/218	-	0 09	X		Detected in most samples, one outlier concentration of 1730 pCi/L	Yes
						is not used in ConTox screen, next highest concentration is 668 pCi/L	Yes
Uranium 233,234	233/233	0	0 41	* X		Uranium isotopes are detected in nearly all samples, they may be	Yes
Uranium 235	182/233	0	<0 01	* X		nants pending further evaluation of the data	Yes
Uranium 238	227/227	0	0 43	* X			Yes

(1) Detection frequency and UTL comparison from Table A-4 - No data

(2) Table A-12 p < 0 05 is considered significant

(3) <5% data > 95% UTL and p > 0 05

(4) > 5% data > 95% UTL and p < 0 05

? Either > 5% data > 95% UTL or p < 0 05

* Background mean exceeds OU2 mean

TABLE 3-5
ROCKY FLATS PLANT OU-2
ORGANIC COMPOUNDS DETECTED AT
5% OR GREATER FREQUENCY
NO 1 SANDSTONE

Chemical	Maximum Concentration mg/L	Detection Frequency %
* 1,1,1,2-tetrachloroethane	0 0026	5
1,1,1-trichloroethane	0 13	40
* 1,1,2,2-tetrachloroethane	0 0024	5
1,1-dichloroethane	0 0034	24
1,1-dichloroethene	0 036	33
* 1,2-dichloroethene	0 054	39
* acetone	0 16	9
* benzene	0 001	6
bromodichloromethane	0 018	8
carbon tetrachloride	4 5	59
chloroform	1 1	62
cis-1,2-dichloroethene	0 3	52
methylene chloride	3	34
naphthalene	0 044	10
* p-cymene	0 00076	6
* sec-butyl benzene	0 011	5
tetrachloroethene	13	81
toluene	0 013	10
trans-1,2-dichloroethene	0 0025	12 5
trichloroethene	94	71
bis (2-ethylhexyl) phthalate	0 017	33
benzoic acid	0 056	6
diethyl phthalate	0 31	26
* di-n-butyl phthalate	0 003	6

* Detected at <5% frequency in the UHSU as a whole

TABLE 3-6
ROCKY FLATS PLANT OU-2
ORGANIC COMPOUNDS DETECTED AT 5% OR GREATER FREQUENCY
UHSU GROUNDWATER

Chemical	Maximum Concentration mg/L	Detection Frequency %
1,1,1-trichloroethane	0.54	24
1,1-dichloroethane	0.19	15
1,1-dichloroethene	0.26	23
1,2-dichloroethene	0.17	32
bromodichloromethane	0.02	7
carbon tetrachloride	17	57
chloroform	1.7	58
cis-1,2-dichloroethene	1.4	46
methylene chloride	3.9	26
tetrachloroethene	13	67
toluene	0.01	9
trans-1,2-dichloroethene	0.03	11
trichloroethene	94	62
bis(2-ethylhexyl)phthalate	0.017	38
diethylphthalate	0.31	20
naphthalene	0.09	13
heptachlor epoxide	0.00007	*

* Reported in 1 of 2 samples analyzed

TABLE 3-7
ROCKY FLATS PLANT OU-2
ORGANIC COMPOUNDS DETECTED AT
LESS THAN 5% FREQUENCY
NO 1 SANDSTONE

	Maximum Concentration mg/L	Detection Frequency %
1,1,-dichloropropene	0 0016	4
1,1,2-trichloroethane	0 0006	3
1,2,3-trichlorobenzene	0 00003	3
1,2,4-trichlorobenzene	0 0003	1
1,2-dichloroethane	0 0001	3
1,3-dimethylbenzene	0 0002	1
4-methyl-2-pentanone	0 01	4
1,2,4-trimethylbenzene	0 0001	1
1,3,5-trimethylbenzene	0 00009	1
bromochloromethane	0 03	4
carbon disulfide	0 0008	4
chlorobenzene	0 016	1
chloroethane	0 043	1
chloromethane	0 00029	2
cis-1 3-dichloropropene	0 013	1
dibromomethane	0 065	1
dichlorodifluoromethane	0 00058	1
ethylbenzene	0 015	1
hexachlorobutadiene	0 0012	4
n-butyl benzene	0 0013	4
styrene	0 014	3
total xylene	0 053	3
trichlorofluromethane	0 00057	1

TABLE 3-8
ROCKY FLATS PLANT OU-2
ORGANIC COMPOUNDS DETECTED AT
LESS THAN 5% FREQUENCY
UHSU GROUNDWATER

Chemical	Maximum Concentration mg/L	Detection Frequency %
1,1,1,2-tetrachloroethane	0 003	3
1,1,2,2-tetrachloroethane	0 18	3
1,1,2-trichloroethane	0 02	2
1,1-dichloropropene	0 002	2
1,2,3-trichlorobenzene	0 0003	2
1,2,3-trichloropropane	0 002	2
1,2,4-trichlorobenzene	0 002	2
1,2-dibromoethane	0 01	1
1,2-dichlorobenzene	0 0001	<1
1,2-dichloroethane	0 0073	3
1,2-dichloropropane	0 02	<1
1,2-dimethylbenzene (o-xylene)	0 0002	3
1,3-dichlorobenzene	0 002	2
1,3-dichloropropane	0 0003	1
1,3-dimethylbenzene (m-xylene)	0 0003	2
1,4-dichlorobenzene	0 0003	1
2-hexanone	0 005	2
4-methyl-2-pentanone	0 01	2
acetone	0 16	4
benzene	0 005	5
1,2,4-trimethylbenzene	0 0001	2
1,3,5-trimethylbenzene	0 001	1
benzoic acid	0 056	4
bromobenzene	0 0003	1
bromoform	0 006	1
chlorobenzene	0 02	1
chloroethane	0 04	1
chloromethane	0 005	1
cis-1,3-dichloropropene	1 7	1
dibromomethane	1 7	2
dichlorodifluoromethane	0 0006	1
ethylbenzene	0 02	2
hexachlorobutadiene	0 0012	3
n-butylbenzene	0 001	2
o-chlorotoluene	0 003	0 05
p-chlorotoluene	0 0003	<1

TABLE 3-8
(Concluded)

	Maximum Concentration mg/L	Detection Frequency %
p-cymene	0 0008	4
1,2-dibromo-3-chloropropane	0 004	1
sec-butylbenzene	0 2	3
sec-dichloropropane	0 01	1
styrene	0 01	3
tert-butylbenzene	0 0004	1
vinyl chloride	0 86	3
di-n-butylphthalate	0 003	4

TABLE 3-9
ROCKY FLATS OU-2
NO. 1 SANDSTONE GROUNDWATER
NONCARCINOGENS - CON/TOX SCREEN
(Organics and Total Metals)

Chemical	Maximum Value(ppm)	Inhalation RFD	Oral RFD	Risk Factor	Risk Index	Rank	Cumulative Percent
carbon tetrachloride (1)	4 5	n/a	7 00E-04	6 43E+03	8 00E-01	1	80 0
tetrachloroethene (1)	13	n/a	1 00E-02	1 30E+03	1 62E-01	2	96 2
chloroform (1)	1 1	n/a	1 00E-02	1 10E+02	1 37E-02	3	97 5
methylene chloride (2,1)	3	9 00E-01	6 00E-02	5 00E+01	6 22E-03	4	98 2
manganese(3)	4 92	n/a	1 00E-01	4 92E+01	6 12E-03	5	98 8
barium (2,1)	3 09	n/a	7 00E-02	4 41E+01	5 49E-03	6	99 3
cis-1,2-dichloroethene (2)	0 3	n/a	1 00E-02	3 00E+01	3 73E-03	7	99 7
1,2-dichloroethene (2)	0 054	n/a	9 00E-03	6 00E+00	7 47E-04	8	99 8
1,1-dichloroethene (1)	0 036	n/a	9 00E-03	4 00E+00	4 98E-04	10	99 9
acetone (1)	0 16	n/a	1 00E-01	1 60E+00	1 99E-04	11	99 9
1,1,1-trichloroethane (2)	0 13	3 00E-01	9 00E-02	1 44E+00	1 80E-04	12	99 9
cyanide(1)	0 0265	n/a	2 00E-02	1 33E+00	1 65E-04	13	99 9
trans-1,2-dichloroethene (1)	0 025	n/a	2 00E-02	1 25E+00	1 56E-04	14	100 0
naphthalene (2)	0 044	n/a	4 00E-02	1 10E+00	1 37E-04	15	100 0
bromodichloromethane (1)	0 018	n/a	2 00E-02	9 00E-01	1 12E-04	16	100 0
bis(2-ethylhexyl)phthalate (1)	0 017	n/a	2 00E-02	8 50E-01	1 06E-04	17	100 0
diethyl phthalate (1)	0 31	n/a	8 00E-01	3 88E-01	4 82E-05	18	100 0
toluene (1)	0 013	1 10E-01	2 00E-01	1 18E-01	1 47E-05	19	100 0
1,1,1,2-tetrachloroethane (1)	0 0026	n/a	3 00E-02	8 67E-02	1 08E-05	20	100 0
1,1-dichloroethane (2,3)	0 0034	1 40E-01	1 00E-01	3 40E-02	4 23E-06	21	100 0
benzoic acid (1)	0 056	n/a	4 00E+00	1 40E-02	1 74E-06	22	100 0
di-n-butylphthalate	0 003	n/a	1 00E+01	3 00E-04	3 73E-08	23	100 0

Sources:
1=Iris
2=Heast 1992
3=Heast 1991
RFDs are in units of mg/kg-day and slope factors are in units of 1/(mg/kg-day)

TABLE 3-10
ROCKY FLATS OU-2
NO. 1 SANDSTONE GROUNDWATER
CARCINOGENS - CON/TOX SCREEN
(Organics and Total Metals)

Chemical	Maximum Value(ppm)	Inhalation Slope Factor	Oral Slope Factor	Risk Factor	Risk Index	Rank	Cumulative Percent
trichloroethene (2)	94	5 95E-03	1 10E-02	1.03E+00	4 28E-01	1	42 8
tetrachloroethene (2)	13	1 80E-03	5 10E-02	6 63E-01	2 74E-01	2	70 3
carbon tetrachloride (1)	4 5	5 25E-02	1 30E-01	5 85E-01	2 42E-01	3	94 5
chloroform (1)	1 1	8 00E-02	6 10E-03	8 80E-02	3 64E-02	4	98 1
methylene chloride (1)	3	1 60E-03	7 50E-03	2 25E-02	9 31E-03	5	99 0
1,1-dichloroethene (1)	0 036	1 75E-01	6 00E-01	2 16E-02	8 94E-03	6	99 9
bromodichloromethane (1)	0 018	n/a	6 20E-02	1 12E-03	4 62E-04	7	100 0
bis(2-ethylhexyl)phthalate (1)	0 017	n/a	1 40E-02	2 38E-04	9 85E-05	8	100 0
1,1,1,2-tetrachloroethane (1)	0 0026	2 60E-02	2 60E-02	6 76E-05	2 80E-05	9	100 0
benzene (2,1)	0 001	2 90E-02	2 90E-02	2 90E-05	1 20E-05	10	100 0
				2 42E+00			

Sources
1=Iris
2=Heast 1991
RFDs are in units of mg/kg-day and slope factors are in units of 1/(mg/kg-day)

TABLE 3-12
ROCKY FLATS OU-2
GROUNDWATER (UHSU)
NONCARCINOGENS - CON/TOX SCREEN
(Organics and Dissolved Metals)

Chemical	Maximum Value(ppm)	Inhalation RFD	Oral RFD	Risk Factor	Risk Index	Rank	Cumulative Percent
carbon tetrachloride (1)	17	n/a	7 00E-04	2 43E+04	9 28E-01	1	92 8
tetrachloroethene (1)	14	n/a	1 00E-02	1 40E+03	5 35E-02	2	98 2
chloroform (1)	1 7	n/a	1 00E-02	1 70E+02	6 50E-03	3	98 9
cis-1,2-dichloroethene (2)	1 4	n/a	1 00E-02	1 40E+02	5 35E-03	4	99 4
methylene chloride (2,1)	3 9	9 00E-01	6 00E-02	6 50E+01	2 49E-03	5	99 6
manganese (3)	3 9	n/a	1 00E-01	3 90E+01	1 49E-03	6	99 8
1,1-dichloroethene (1)	0 26	n/a	9 00E-03	2 89E+01	1 10E-03	7	99 9
barium (1)	0 68	n/a	7 00E-02	9 71E+00	3 71E-04	8	99 9
1,1,1-trichloroethane (2)	0 54	3 00E-01	9 00E-02	6 00E+00	2 29E-04	9	100 0
zinc (2)	0 76	n/a	2 00E-01	3 80E+00	1 45E-04	10	100 0
naphthalene (2)	0 09	n/a	4 00E-02	2 25E+00	8 60E-05	11	100 0
1,1-dichloroethane (2,3)	0 19	1 40E-01	1 00E-01	1 90E+00	7 26E-05	12	100 0
trans-1,2-dichloroethene (1)	0 03	n/a	2 00E-02	1 50E+00	5 73E-05	13	100 0
bromodichloromethane (1)	0 02	n/a	2 00E-02	1 00E+00	3 82E-05	14	100 0
bis(2-ethylhexyl)phthalate (1)	0 017	n/a	2 00E-02	8 50E-01	3 25E-05	15	100 0
diethyl phthalate (1)	0 31	n/a	8 00E-01	3 88E-01	1 48E-05	16	100 0
toluene (1)	0 01	1 10E-01	2 00E-01	9 09E-02	3 48E-06	17	100 0
				2 62E+04			

Sources
1=Iris
2=Heast 1992
3=Heast 1991
RFDs are in units of mg/kg-day and slope factors are in units of 1/(mg/kg-day)

TABLE 3-13
ROCKY FLATS OU-2
GROUNDWATER (UHSU)
CARCINOGENS - CON/TOX SCREEN
(Organics and Dissolved Metals)

Chemical	Maximum Value(ppm)	Inhalation Slope Factor	Oral Slope Factor	Risk Factor	Risk Index	Rank	Cumulative Percent
trichloroethene (2)	94	5 95E-02	1 10E-02	5 59E+00	6 36E-01	1	63 6
carbon tetrachloride (1)	17	5 25E-02	1 30E-01	2 21E+00	2 51E-01	2	88 8
tetrachloroethene (2)	13	1 80E-03	5 10E-02	6 63E-01	7 54E-02	3	96 3
1,1-dichloroethene (1)	0 26	1 75E-01	6 00E-01	1 56E-01	1 78E-02	4	98 1
chloroform (1)	1 7	8 00E-02	6 10E-03	1 36E-01	1 55E-02	5	99 7
methylene chloride (1)	3 9	1 60E-03	7 50E-03	2 93E-02	3 33E-03	6	100 0
bromodichloromethane (1)	0 02	n/a	6 20E-02	1 24E-03	1 41E-04	7	100 0
bis(2-ethylhexyl)phthalate (1)	0 017	n/a	1 40E-02	2 38E-04	2 71E-05	8	100 0
				8 79E+00			

Sources
1=Iris
2=Heast 1991
RFDs are in units of mg/kg - day and slope factors are in units 1/(mg/kg-day).

TABLE 3-14
ROCKY FLATS OU-2
GROUNDWATER (UHSU)
RADIONUCLIDES - CON/TOX SCREEN
(Dissolved)

Chemical	Maximum Value(pCi/L)	Inhalation Slope Factor	Oral Slope Factor	Risk Factor	Risk Index	Rank	Cumulative Percent
uranium-235	1 5	n/a	2 40E-07	3 60E-07	9 77E-01	1	97 7
americium-241(1)	21 3	n/a	2 40E-10	5 11E-09	1 39E-02	2	99 1
uranium-238	76	n/a	2 10E-11	1 60E-09	4 33E-03	3	99 5
uranium-233,234	43	n/a	3 00E-11	1 29E-09	3 50E-03	4	99 9
radium-226	2 82	n/a	1 20E-10	3 38E-10	9 18E-04	5	99 9
plutonium-239/240(1)	0 8	n/a	2 30E-10	1 84E-10	4 99E-04	6	100 0
strontium-89/90(1)	0 39	n/a	3 30E-11	1 29E-11	3 49E-05	7	100 0
				3 69E-07			

Sources
1=Heast 1992

Oral Slope factors are in units of risk per pCi

TABLE 3-16
ROCKY FLATS PLANT OU-2
CHEMICALS OF CONCERN
GROUNDWATER (UHSU)

Noncarcinogenic Effects	Carcinogenic Effects	Radionuclides
cis-1,2-dichloroethene	1,1-dichloroethene	americium 241
carbon tetrachloride	carbon tetrachloride	uranium - 235
chloroform	chloroform	[plutonium 239/240]*
tetrachloroethene	tetrachloroethene	[radium 226]*
	trichloroethene	

* Probable chemicals of concern if uranium isotopes are determined not to be site-related (see text)

4.0
SUBSURFACE SOIL CHEMICALS OF CONCERN

4.1 DATA EVALUATION

Chemicals of concern in subsurface soil were selected using the data set identified in Table 2-2 This includes borehole samples collected in 1987 by Weston and in 1991-1992 by W-C Borehole samples were analyzed for volatiles, semivolatiles, pesticides, and metals The data received from RFEDs were reviewed and edited using the steps and criteria outlined in Section 2 1 to develop a data set for further evaluation

The data set used to identify potential chemicals of concern for exposure to subsurface soils was restricted to samples collected above the water table so as to avoid the possibility of collecting soil samples that may be of cross-contaminated by groundwater

Several common laboratory contaminants detected in subsurface soil samples (bis(2-ethylhexyl)phthalate, di-n-butylphthalate, methylene chloride, and acetone) were evaluated to judge whether their occurrence may be due to cross-contamination from sampling or analytical procedures If these compounds are found in consistently low concentrations regardless of sampling location, it is probable that they are not related to waste sources in OU-2 and can be eliminated from further consideration as chemicals of concern The purposes of this evaluation, a criteria of 10 times the detection limit was used as the value to screen out a compound as a laboratory contaminant The evaluation of these compounds follows

Bis(2-ethylhexyl)phthalate/di-n-butylphthalate Bis(2-ethylhexyl)phthalate and di-n-butylphthalate were detected in subsurface soil samples across OU-2 In most cases these phthalates are detected below the detection limit of 330 μg/kg The data suggest that the phthalates in OU-2 are not related to waste or contaminant disposal Bis (2-ethylhexyl) phthalate was detected a higher concentration (12,000 μg/kg) in BH 3887 at a depth of about 20 feet Nevertheless, this compound is not considered to be an OU-2 contaminant of concern

Methylene Chloride Methylene chloride was detected in subsurface soil samples Concentrations range from the detection limit of 5 μg/kg up to 10 times the 5 μg/kg Only one subsurface soil sample from source borehole BH 2587 shows a detected concentration of 50 μg/kg or 10 times the detection limit Since the frequency of detection at concentrations greater than 10 times the detection limit is low, methylene chloride is considered a laboratory contaminant and not an OU-2 contaminant

Acetone Elevated concentrations of acetone were observed in six subsurface soil samples collected from Trench T-3 (IHSS 110), Trench T-4 (IHSS 111 1), and Trench T-11 (IHSS 111 8) in the Northeast Trenches Area The acetone analytical results in this area range from 68 to 26,000 µg/kg Of the six borehole samples, only boreholes 10191, BH 4187, and BH 4287 had concentrations of other VOCs identified Acetone is not characteristic of soil contamination in OU-2, but may be retained as a "special case" chemical of concern in the northeast Trenches Area

Historical information indicates that acetone still bottoms were located in the 903 Pad Area However, analytical results for acetone in samples taken from this area show concentrations at less than 50 µg/kg

Acetone was detected above the criteria of 10 times the detection limit in numerous subsurface soil samples in the Mound Area However, these samples did not have detected concentrations of other VOCs, and, therefore, acetone is considered to be a laboratory contaminant in these samples

4.2 BACKGROUND COMPARISON FOR INORGANIC COMPOUNDS

Tables 4-1 and 4-2 summarize the results of comparing concentrations of metals and radionuclides in borehole samples to background levels Metals and radionuclides that did not exceed background levels were eliminated from further consideration as potential chemicals of concern The background comparison process is described in Appendix A

NOTE: An error has been noted in some reported analyses in the electronic data file for the background metals data from the Background Geochemical Characterization Report that is likely to affect the results of the background comparison. The error is being corrected and new results will be presented in the revised draft of this document. The chemicals of concern presented in this section are therefore preliminary.

4.3 FREQUENCY OF DETECTION

Compounds detected at a frequency of 5 percent or greater (excepting the laboratory contaminant eliminated above) were considered potential chemicals of concern and are listed in Table 4-3 Except for the probable laboratory contaminants identified in Section 4 1, these compounds are included in the concentration/toxicity screens that accompany this section

Compounds detected in subsurface soils at less than 5 percent frequency are listed in Table 4-4 The potential for exposure to infrequently detected compounds is low Nevertheless, concentrations of infrequently detected organic compounds were further evaluated as described in Section 4 5 to identify those that could contribute significantly to risk if the chemicals were associated with elevated concentrations of several chemicals of concern at exposure areas

4.4 CONCENTRATION/TOXICITY SCREENS

Concentration/toxicity screens were used to identify chemicals, based on concentration and toxicity, that could contribute significantly to risk and to eliminate chemicals from further consideration that contribute insignificantly to risk The screen was performed on chemicals detected above background and at a frequency of 5 percent or greater The concentration/toxicity screen process was explained in Section 2 5 Results of the screen for borehole data are shown in Tables 4-5 (Noncarcinogenic Effects), 4-6 (Carcinogenic Effects), and 4-7 (Radionuclides) Note the con/tox screens may require revision following the corrections to the background data comparison

4.5 EVALUATION OF INFREQUENTLY DETECTED COMPOUNDS

Compounds detected at less than 5 percent frequency may be eliminated from further consideration because the potential for exposure is low However, these compounds were further screened so as not to neglect infrequently detected compounds that could contribute significantly to risk if the chemicals were associated with elevated concentrations of several chemicals at exposure areas In this screen, maximum concentrations of infrequently detected compounds were compared to risk-based screening values using the approach outlined in Section 2 5 and described in greater detail in Appendix B

Results of the comparison are shown in Table 5, B-7 and B-8 No infrequently detected compounds in subsurface soils were present at concentrations greater than the screening values used in the analysis Therefore, no "special case" chemicals of concern are identified for subsurface soils, except acetone in the northeast Trenches Area (see Section 4 1)

4.6 SUMMARY OF CHEMICALS OF CONCERN IN SUBSURFACE SOIL

Chemicals of concern in subsurface soil identified by the approach described above are listed in Table 4-8 These are arsenic, tetrachloroethene, uranium-238, americium 241, and plutonium 239/240

TO BE REVISED
TABLE 4-1
ROCKY FLATS PLANT OU-2
SUMMARY OF BACKGROUND COMPARISON
METALS IN SUBSURFACE SOIL, mg/kg

Note An error has been noted in the background metals data which is likely to affect the results of the background comparison The error is being corrected and new results will be presented in the revised draft of this document.

Analyte	DF % (1)	% Data > 95% UTL (1)	ANOVA p (2)	Potential Contaminant? No (3)	Potential Contaminant? Yes (4)	Spatial/Temporal/Other (see text)	OU-2 Contaminant?
Aluminum	100	0	0 43	x			No
Antimony	4	0	<0 01*	x			No
Arsenic	94	13	<0 01		x		Yes
Barium	83	0	<0 01*	x			No
Beryllium	47	0	<0 01*	x			No
Cadmium	45	0	0 01*	x			No
Cesium	91	0	<0 01*	x			No
Chromium	98	0	0 02*	x			No
Cobalt	55	0	<0 01*	x			No
Copper	84	0	<0 01*	x			No
Lead	99	2	<0 01*	x			No
Lithium	91	0	<0 01*	x			No
Manganese	100	0	0 96	x			No
Mercury	20	1 3	<0 01		?	3 hits above background UTL	No
Molybdenum	33	0	<0 01*	x			No
Nickel	79	0	<0 01*	x			No
Selenium	7	0	<0 01*	x			No
Silver	13	0	<0 01*	x			No
Strontium	82	0	<0 01*	x			No
Thallium	12	0	<0 01*	x			No
Tin	24	0	0 09	x			No
Vanadium	97	0	0 08	x			No
Zinc	98	0	<0 01*	x			No

(1) Detection frequency and UTL comparison from Table A-5
(2) Table A-13 p < 0 05 is considered significant.
(3) <5% data > 95% UTL and p > 0 05
(4) > 5% data > 95% UTL and p < 0 05
? Either >5% data > 95% UTL or p < 0 05

*Background mean exceeds OU2 mean

(4034-263-0049-340)(RT4-1)(7/19/93 11 54 AM)

TABLE 4-2
ROCKY FLATS PLANT OU-2
SUMMARY OF BACKGROUND COMPARISON
RADIONUCLIDES IN SUBSURFACE SOIL, pCi/g
VADOSE ZONE

Analyte	DF % (1)	% Data > 95% UTL (1)	ANOVA p (2)	Potential Contaminant? No (3)	Potential Contaminant? Yes (4)	Spatial/Temporal/Other (see text)	Retain for Further Evaluation?
Americium 241	83	-	-		?	Probable contaminant	Yes
Cesium 137	66	50	-		?	Possible contaminant	Yes
Plutonium 239	100	-	-		?	Probable contaminant	Yes
Plutonium 239,240	85	-	-		?	Probable contaminant	Yes
Radium 226	90	4	<0 01*	X			No
Radium 228	100	9	0 78		?		?
Strontium 89,90	70	0	<0 01*	X		OU-2 mean < Sr89,90 bknd	No
Strontium 90	98	-	-	X			No
Tritium (pCi/L)	73	10	<0 01*		?		?
Uranium 233,234	100	2	0 08	X		OU-2 mean < U235 bknd	No
Uranium 235	88	2	<0 01*	X			No
Uranium 235,236	100	-	-	X			No
Uranium 238	100	4	<0 01		?	Possible contaminant	Yes

(1) Detection frequency and UTL comparison from Table A-6
(2) Table A-14 p < 0 05 is considered significant
(3) <5% data > 95% UTL and p > 0 05
(4) > 5% data > 95% UTL and p < 0 05
* Background mean exceed OU2 mean
? Either > 5% data > 95% UTL or p < 0 05

TABLE 4-3
ROCKY FLATS PLANT OU-2
ORGANIC COMPOUNDS DETECTED AT
5% or GREATER FREQUENCY
SUBSURFACE SOIL

	Maximum Concentration, mg/kg	Detection Frequency %
*Acetone	26	34
*Methylene chloride	037	32
1,2-Dichloroethane	0 120	12
2-Butanone	0.15	7
1,1,1-Trichloroethane	13	7
Trichloroethene	120	5 3
Toluene	1 1	34
Tetrachloroethene	13000	11
Total xylenes	0 23	5
*Bis(2-ethylhexyl)phthalate	12	47
N-Nitrosodiphenylamine	0 37	18
*Di-n-butyl phthalate	3 4	10

* Probable laboratory or field contaminant (see text) However, acetone at the NE Trenches Area may be site-related

TABLE 4-4
ROCKY FLATS PLANT OU-2
ORGANIC COMPOUNDS DETECTED AT
LESS THAN 5% FREQUENCY
SUBSURFACE SOIL

	Maximum Concentration mg/kg	Detection Frequency %
1,1,2-Trichloroethane	0 027	0 7
1,1-Dichloroethane	0 008	0 3
1,2-Dichloroethane	0 09	2
2-Chloroethylvinylether	0 031	0 7
Benzene	0 012	0 3
Bromomethane	0 006	0 3
Carbon tetrachloride	140	4
Chloroethane	0 050	0 3
Chloroform	8 8	3
Cis-1,3-dichloropropene	0 006	0 3
Ethylbenzene	0 78	1
Styrene	0 17	0 3
Aroclor-1254	8 9	2
4,4'-DDT	0 14	0 35
Pentachlorophenol	0 095	0 7
1,4-Dichlorobenzene	0 043	0 4
Fluoranthene	1 0	1 8
Pyrene	1 3	2 2
Di-n-octyl phthalate	0.26	0 4
Phenanthrene	2 7	1 8
2-Methylnaphthalene	8 1	1
Acenaphthene	0 28	0 7
Benzo(a)pyrene	0 48	0 7
Chrysene	0 42	0 7
Naphthalene	2 0	0 7
Benzoic Acid	0 4	0 4

TABLE 4-5

ROCKY FLATS OU-2
SUBSURFACE SOIL
NONCARCINOGENS - CON/TOX SCREEN
(Organics and Metals)

Chemical	Maximum Value (ppm)	Inhalation RFD	Oral RFD	Risk Factor	Risk Index	Rank	Cumulative Percent
tetrachloroethene(1)	13000	n/a	1 00E-02	1 30E+06	9 13E-01	1	91 3
arsenic(1)	37	n/a	3 00E-04	1 23E+05	8 66E-02	2	100 0
1,1,1-trichlorethane(2)	13	3 00E-01	9 00E-02	1 44E+02	1 01E-04	3	100 0
toluene(1)	1 1	1 10E-01	2 00E-01	1 00E+01	7 02E-06	4	100 0
2-butanone(1)	0 15	3 00E-01	6 00E-01	5 00E-01	3 51E-07	5	100 0
total xylenes (1)	0 23	n/a	2 00E+00	1 15E-01	8 08E-08	6	100 0
				1 42E+06			

Sources

(1) Iris

(2) Heast 1992

Toxicity factors are in units of mg/kg-day (RFDs) and 1/(mg/kg-day) (slope factors)

TABLE 4-6

ROCKY FLATS OU-2
SUBSURFACE SOIL
CARCINOGENS - CON/TOX SCREEN
(Organics and Metals)

Chemical	Maximum Value(ppm)	Inhalation Slope Factor	Oral Slope Factor	Risk Factor	Risk Index	Rank	Cumulative Percent
tetrachloroethene(2)	13000	1 80E-03	5 10E-02	6 63E+02	5 44E-01	1	54 4
arsenic(1)	37	1 50E+01	1 75E+00	5 55E+02	4 55E-01	2	99 9
trichloroethene(2)	120	5 95E-03	1 10E-02	1 32E+00	1 08E-03	3	100 0
1,2-dichloroethane (1)	0 12	9 10E-02	9 10E-02	1 09E-02	8 96E-06	4	100 0
N-nitrosodiphenylamine(1)	0 37	n/a	4 90E-03	1 81E-03	1 49E-06	5	100 0
				1 22E+03			

Sources
(1) Iris
(2) Heast 1991

Toxicity factors are in units of mg/kg-day (RFDs) and 1/(mg/kg-day) (slope factors)

TABLE 4-7

ROCKY FLATS OU-2
SUBSURFACE SOIL
RADIONUCLIDES - CON/TOX SCREEN

Chemical	Maximum Value(pCi/g)	Inhalation Slope Factor	Oral Slope Factor	Risk Factor	Risk Index	Rank	Cumulative Percent
uranium-238 (1)	113	2 40E-08	1 60E-11	2 71E-06	4 19E-01	1	41 9
plutonium-239/240(1)	68	3 80E-08	2 30E-10	2 58E-06	3 99E-01	2	81 8
americium-241(1)	25	3 20E-08	2 40E-10	8 00E-07	1 23E-01	3	94 1
plutonium-239(1)	10	3 80E-08	2 30E-10	3 80E-07	5 87E-02	4	100 0
radium-228 (1)	2 6	6 60E-10	1 00E-10	1 72E-09	2 65E-04	5	100 0
tritium (1) (pCi/L)	1500	7 80E-14	5 40E-14	1 17E-10	1 81E-05	6	100 0
cesium-137(1)	2 4	1 90E-11	2 80E-11	6 72E-11	1 04E-05	7	100 0
						8	100 0
				6 48E-06			

Sources:
(1) Heast 1992

Slope factors are in units of 1/pCi

TABLE 4-8
ROCKY FLATS PLANT OU-2
CHEMICALS OF CONCERN
SUBSURFACE SOIL

Noncarcinogenic Effects	Carcinogenic Effects	Radionuclides
arsenic	arsenic	americium 241
tetrachloroethene	tetrachloroethene	plutonium 239/240

5.0
SURFACE SOIL PRELIMINARY CHEMICALS OF CONCERN

5.1 DATA EVALUATION

Chemicals of concern in surface soil were selected using the data set identified in Table 2-2 This includes surface soil samples collected in 1991 by Stoller (radionuclides) and in 1993 by Woodward-Clyde Surface soil samples were analyzed for semivolatiles, pesticides, metals, and radionuclides Not all analytical results for surface soils have been received All data received as of June 6, 1993, is included in this evaluation. As of June 1993, approximately the following amount of 1993 surface soil data has been received semivolatile organics (100%), pesticides (100%), metals (18%) and radionuclides (50%) Surface soil chemicals of concern are identified on a preliminary basis until all the data has been received and evaluated

Several organic compounds detected in surface soil samples (benzoic acid, polycyclic aromatic hydrocarbons (PAHs), PCBs, and delta-BHC) were evaluated to judge whether their occurrence is likely to be due to waste disposal properties in OU-2 or not This evaluation is described below

- Benzoic Acid

  Benzoic acid was detected in most surface soil samples obtained within OU-2 Benzoic acid concentrations are all estimated below the CRDL of 1,600 mg/kg Benzoic acid results range from 0.051 to 0 07 mg/kg and are evenly distributed across OU-2 Therefore, benzoic acid is not considered as a waste-related contaminant to OU-2

- PAHs

  Pyrene, fluoranthene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(a)anthracene and other PAHs were detected in surface soil samples obtained within OU-2 These semivolatiles are typical hydrocarbon combustion by-products from vehicular traffic PAHs were detected in surface soil samples collected around the Pallet Burn Site (IHSS 154), at estimated concentrations ranging from 38 to 200 µg/kg The concentration of these PAHs load similar to other PAHs observed across OU-2, which ranged from approximately 47 to 390 µg/kg The PAHs detected around IHSS 154 are likely due to vehicular traffic and are not due to waste-related contaminants Therefore, these SVOCs are not considered to be waste-related contaminants in OU-2

- <u>PCBs</u>

The PCBs Aroclor-1254 and Aroclor-1260 were detected in surface soil samples obtained from Trench T-1 (IHSS 108) and the Mound Site (IHSS 113) It is believed that these PCBs are localized contaminants related to the Mound Area They are evaluated in Appendix B by comparing maximum concentrations to risk-based screening concentrations

- <u>delta-BHC</u>

The insecticide delta-BHC was detected in one of 52 surface soil samples It's occurrence is probably due to maintenance operations It is not considered an OU-2 contaminant

- <u>Bis(2-ethylhexyl)phthalate</u>

Bis(2-ethylhexyl)phthalate was detected in 9 of 40 surface soil samples widely distributed across OU-2 Concentrations ranged from 49 to 510 µg/kg In most cases, bis(2-ethylhexyl) phthalate was detected below the detection limit of 330 µg/kg The data suggest that bis(2-ethylhexyl)phthalate in OU-2 is not related to waste or contaminant disposal in OU-2.

- <u>4,4-DDT</u>

The pesticide 4,4-DDT was detected in one of 52 surface soil samples at a concentration of 26 µg/kg This low concentration is probably residue from former pest management activities at the plant or nearby It is not considered an OU-2 contaminant

5.2 BACKGROUND COMPARISON FOR INORGANIC COMPOUNDS

Tables 5-1 and 5-2 summarize the results of comparing concentrations of metals and radionuclides in surface samples to background levels Metals and radionuclides that did not exceed background levels were eliminated from further consideration as potential chemicals of concern The background comparison process is described in Appendix A Thallium appears to exceed background levels by the ANOVA test

Thallium is not considered an OU-2 contaminant because it was detected in only 2 or 9 samples at low concentrations (0 5 mg/kg)

The radionuclides americium-241, plutonium-239/240, and radium-226 are retained for further evaluation as possible OU-2 contaminants

5.3 FREQUENCY OF DETECTION

Organic compounds detected at a frequency of 5 percent or greater were considered potential chemicals of concern These compounds are listed in Table 5-3 None of the organic compounds detected at 5% or greater frequency are likely to be related to waste sources in OU-2, as described in Section 5 1

Compounds detected in surface soils at less than 5 percent frequency are listed in Table 5-4 The potential for exposure to infrequently detected compounds is low Nevertheless, concentrations of PCBs were further evaluated as described in Section 5 5 Other compounds detected at <5% frequency are not considered site-related

5.4 CONCENTRATION/TOXICITY SCREENS

No site-related organic compounds or metals were identified in surface soils using the available data set, with the exception of the infrequently detected PCBs that are evaluated in Section 5 5 Therefore, a concentration/toxicity screen was performed only for radionuclides of potential concern The concentration/toxicity screen process was explained in Section 2 4 Results of the screen for radionuclides in surface soil are shown in Tables 5-5 Plutonium-239/240 contributes over 99 percent of the total risk factor Americium-241 will be retained for evaluation in the risk assessment even though it contributes only a small fraction of the total risk factor

5.5 EVALUATION OF INFREQUENTLY DETECTED COMPOUNDS

Compounds detected at less than 5 percent frequency may be eliminated from further consideration because the potential for exposure is low However, the PCBs detected in surface soils were further screened to assess the need to evaluate them as "special case" chemicals of concern In this screen, maximum concentrations were compared to risk-based screening values using the approach outlined in Section 2 5 and described in greater detail in Appendix B

Results of the comparison are shown in Table B-8 The PCBs in surface soils were not present at concentrations greater than the screening values, and therefore, they do not warrant inclusion in the risk assessment

5.6 SUMMARY OF PRELIMINARY CHEMICALS OF CONCERN IN SUBSURFACE SOIL

Preliminary site-related chemicals of concern in surface soils in OU-2 are plutonium-239/249 and americium 241 The selection of chemicals of concern will be verified upon receipt and evaluation of the complete analytical results for OU-2 surface soils

TABLE 5-1
ROCKY FLATS PLANT OU-2
SUMMARY OF BACKGROUND COMPARISON
METALS IN SURFACE SOIL, mg/kg

Note Background comparison is preliminary because not all OU-2 analytical results for surface soils were available at the time of preparing this technical memorandum.

Analyte	DF % (1)	% Data > 95% UTL (1)	ANOVA p (2)	Potential Contaminant? No (3)	Potential Contaminant? Yes (4)	Spatial/Temporal/Other (see text)	OU-2 Contaminant?
Aluminum	100	0	0.04 *				No
Arsenic	100	0	<0 01*	x			No
Barium	100	0	<0 01 *	x			No
Chromium	100	0	<0 01*	x			No
Cobalt	100	0	0 04*	x			No
Copper	100	0	<0 01*	x			No
Lead	100	0	0 05 *	x			No
Lithium	100	0	0 01*	x			No
Manganese	100	0	0 01*	x			No
Nickel	100	0	0 06 *	x			No
Selenium	11	0	0 84	x			No
Strontium	100	0	0 68 *	x			No
Thallium	22	0	<0 01		?	Not related to source areas	No
Tin	33	0	<0 01*	x			No
Vanadium	100	0	0 17 *	x			No
Zinc	100	0	0 01*	x			No

(1) Detection frequency and UTL comparison from Table A-7
(2) Table A-15 p < 0 05 is considered significant
(3) <5% data > 95% UTL and p > 0 05 (4) > 5% data > 95% UTL and p < 0 05
* Background mean exceeds OU2 mean ? Either > 5% data > 95% UTL or p < 0 05

TABLE 5-2
ROCKY FLATS PLANT OU-2
SUMMARY OF BACKGROUND COMPARISON
RADIONUCLIDES IN SURFACE SOIL, pCi/g

Note Background Comparison is preliminary because not all OU-2 analytical results for surface soils were available at the time of preparing this technical memorandum

Analyte	DF % (1)	% Data > 95% UTL (1)	ANOVA p (2)	Potential Contaminant? No (3)	Potential Contaminant? Yes (4)	Spatial/Temporal/Other (see text)	OU-2 Contam-inant?
Americium 241	100	93	<0 01		x	Probable contaminant	Yes
Cesium 137	96	0	-*	x			No
Plutonium 239,240	100	95	<0 01		x	Probable contaminant	Yes
Radium 226	100	5	0 85		?		?
Radium 228	100	0	-*	x			No
Strontium 89,90	100	5	0 56	x			No

(1) Detection frequency and UTL comparison from Table A-8
(2) Table A-16 p < 0 05 is considered significant
(3) <5% data > 95% UTL and p > 0 05
(4) > 5% data > 95% UTL and p < 0 05
* Background mean exceeds OU2 mean
? Either > 5% data > 95% UTL or p < 0 05

TABLE 5-3
ROCKY FLATS PLANT OU-2
ORGANIC COMPOUNDS DETECTED AT
5% OR GREATER FREQUENCY
SURFACE SOIL

	Maximum Concentration mg/kg	Detection Frequency %
Benzo(a)anthracene	0 160	17
Benzo(a)pyrene	0 160	17
Benzo(b)fluoranthene	0 24	17
Benzoic acid	0 7	88
Bis(2-ethylhexyl) phthalate	0 51	21
Chrysene	0 2	23
Fluoranthene	0 39	38
Phenanthrene	0 23	25
Pyrene	0 35	46

TABLE 5-4
ROCKY FLATS PLANT OU-2
ORGANIC COMPOUNDS DETECTED AT
LESS THAN 5% FREQUENCY
SURFACE SOIL

	Maximum Concentration mg/kg	Detection Frequency %
Benzo(g,h,i)perylene	0 061	4
Benzo(k)fluoranthene	0 076	4
Di-n-butyl phthalate	1 0	2
Indeno(1,2,3-cd) perylene	0 83	4
4,4'-DDT	0 026	2
Aroclor-1254	0 97	4
Aroclor-1260	0 66	4
delta-BHC	0 023	2

TABLE 5-5
ROCKY FLATS OU-2
SURFACE SOIL
RADIONUCLIDES - CON/TOX SCREEN

Chemical	Maximum Value(pCi/g)	Inhalation Slope Factor	Oral Slope Factor	Risk Factor	Risk Index	Rank	Cumulative Percent
plutonium-239/240(1)	11000	3 80E-08	2 30E-10	4.18E-04	9 92E-01	1	99 2
americium-241(1)	110	3 20E-08	2 40E-10	3 52E-06	8 35E-03	2	100 0
radium-226 (1)	11 8	3 00E-09	1.20E-10	3 54E-08	8 40E-05	3	100 0
				4 22E-04			

Sources.
(1) Heast 1992
Slope factors are in units of 1/pCi

TABLE 5-6
ROCKY FLATS PLANT OU-2
CHEMICALS OF CONCERN
SURFACE SOIL

Radionuclides
Plutonium 239/240
Americium 241

Cowherd C etal 1985 Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination Sites EPA/600/8-85/002

DOE 1993a Final Technician Memorandum No. 8 Revised Phase II RFI/RI Work Plan (Bedrock), 903 Pad Mound, and East Trenches Area, (Operable Unit No 2) Rocky Flats Plant May 1993

DOE 1993b Technical Memorandum No. 5 Exposure Scenarios Human Health Risk Assessment 903 Pad, Mound, and East Trenches Area, Operable Unit No 2 Draft Final Rocky Flats Plant

EG&G 1992a Final Background Geochemical Characterization Report, Rocky Flats Plant, Golden, Colorado September

EG&G 1992b OU-2 Domestic Water Supply Simulations Earth Resources Division September

Gilbert 1987 Statistical Methods for Environmental Pollution Monitoring Van Nostrand Reinhold Co, New York, NY

HEAST 1991 Health Effects Assessment Summary Tables Annual FY-1991 OERR 9200.6-303

HEAST 1992 Health Effects Assessment Summary Tables Annual FY-1992 OERR 9200 6-303 March

IRIS 1993 Integrated Risk Information System On-line database

EPA 1989a Risk Assessment Guidance for Superfund- Volume I, Human Health Evaluation Manual (Part A) EPA/540/1-89/002 December

EPA 1989b Exposure Factors Handbook

EPA 1989b Statistical Analysis of Ground Water Monitoring Data at RCRA Facilities, Interim Final Guidance April

EPA 1991a Risk Assessment Guidance for Superfund- Volume I, Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals) Interim 9285 7-01B December

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EPA 1992a Guidance for Data Useability in Risk Assessment (Part B). Final 9285 7-09B May

EPA 1992b Analysis of Ground Water Monitoring Data at RCRA Facilities, Addendum to Final Guidance July

EPA 1992c Dermal Exposure Assessment Principles and Applications EPA/800/8-91/011B

Wester et al 1990 Fundamentals of Applied Toxicology 15 510-516

Yang et al 1989 Bulletin of Environmental Contaminants and Toxicology 43 207-214

APPENDIX A

APPENDIX A
BACKGROUND COMPARISON
FOR METALS AND RADIONUCLIDES

Concentrations of metals and radionuclides detected in soil and groundwater in OU-2 were compared to background concentrations reported in the Background Geochemical Characterization Report (EG&G 1992) to help distinguish inorganic compounds that are naturally-occurring within background range from compounds that occur in elevated concentrations due to chemical releases in OU-2 The procedures applied in the background comparison are shown in the flow chart in Figure A-1 Each step is briefly described below

Step 1 - Categorize OU-2 Samples and Background Data

Background data and OU-2 samples were classified by lithologic unit (for groundwater) and by surface vs subsurface soil

Step 2 - Comparison to Background Tolerance Limits

OU-2 data were compared to the 95% upper tolerance limit (UTL) of the background results If more than 5% of the data exceeded the UTL, the compound was retained for further evaluation If 5% or less of the data exceeded the UTL, the compound can be considered to be within background range, although further analysis by ANOVA may be performed Tolerance limits define a range that contains at least P% of a population with p% probability (level of confidence) A probability is associated with the tolerance limits since they are estimated from the data set and therefore have some level of uncertainty associated with them For the tolerance limit to be useful in decision making, both "p" and "P" are chosen to be large, in this case p=0 95 and P=95% A one-sided tolerance is appropriate for analytes for which increase over background are indicative of potential contamination If less than 5% of the non-background results for a given analyte exceed the upper 95% tolerance limit (UTL) of the background results, then the non-background and background populations were considered equivalent Consequently, these analytes can be deleted from the list of potential contaminants based on background comparison If greater than 5% of the non-background results exceed the background UTL, Step 3 is performed The comparison to UTL was performed using the detection limit as the concentration for non-detections

Step 3 - Percentage of Non-Detections

Are there more than 50% non-detections in the grouped background and non-background observations? If so, the Wilcoxon Rank Sum test is an appropriate analysis

Step 4 - Wilcoxon Sum Rank Test

The Wilcoxon Rank Sum test may be used if there are more than 50% non-detections in the grouped background and non-background data In the background comparison performed for this technical memorandum, all data were evaluated using nonparametric ANOVA (Steps 5 through 8) ANOVA requires at least three observations from the non-background area

Step 5 - Distribution of Data

Were the data normally distributed? In using ANOVA it is necessary to identify sample distributions (Step 5) and equality of variances (Step 6) to determine whether non-parametric (Step 7) or parametric (Step 8) ANOVA methods should be used Non-detections were included using a value equal to one-half of the detection limit

Normality of the raw data was evaluated by examining the results of the Shapiro-Wilk test or the Lillifors variation on the Kolmogov-Smirnoff test If the data was normally distributed, Step 6 was performed next If the data was not normally distributed, it was determined if the degree of non-normality was sufficient to invalidate the parametric ANOVA test If the departure from normality was substantial and if data transformations could not achieve normality, then non-parametric statistical methods (Step 7) were used for evaluating the data Variance is a measure of dispersion of a set of observations around the mean of a random variable If the variances of the background and non-background populations are equal, and the data are normally distributed (Step 5), then parametric one-way ANOVA tests are used

With one exception, data for metals or radionuclides were not normally distributed Therefore, Step 6 was generally not performed and the data were evaluated by Step 7, non-parametric ANOVA

Step 6 - Equality of Variance

Are the variances of the background and the non-background data equal? (This step only applies to normally distributed data)

Step 7 - Non-parametric Test

If data are not normally distributed or the variances are not equal, the Kruskal-Wallis non-parametric test is used A non-parametric ANOVA, such as the Kruskal-Wallis test, evaluates differences in the mean rankings of the data (rather than the raw data or transformations of the raw data) Parametric ANOVA was used if both background and non-background data were normally distributed, and the variances are equal

Step 8 - Parametric Test

If the data are normally distributed and the variances are equal, then a parametric test is used (used in one case)

The tables on the following pages present the results of the background comparisons for metals and radionuclides in groundwater, subsurface soil, and surface soil Explanatory notes precede the tables

Table A-1	95% UTL Comparison	Dissolved Metals in Groundwater
Table A-2	95% UTL Comparison	Total Metals in Groundwater (No 1 Sandstone only)
Table A-3	95% UTL Comparison	Total Radionuclides in Groundwater (No 1 Sandstone)
Table A-4	95% UTL Comparison	Dissolved Radionuclides in Groundwater (UHSU)
Table A-5	95% UTL Comparison	Metals in Subsurface Soil
Table A-6	95% UTL Comparison	Radionuclides in Subsurface Soil
Table A-7	95% UTL Comparison	Metals in Surface Soil
Table A-8	95% UTL Comparison	Radionuclides in Surface Soil
Table A-9	ANOVA Comparison	Total Metals in Groundwater (No 1 Sandstone)
Table A-10	ANOVA Comparison	Dissolved Metals in Groundwater (UHSU)
Table A-11	ANOVA Comparison	Total Radionuclides in Groundwater (No 1 Sandstone)
Table A-12	Background Comparison	Dissolved Radionuclides in Groundwater
Table A-13	Background Comparison	Metals in Subsurface Soil
Table A-14	Background Comparison	Radionuclides in Subsurface Soil
Table A-15	Background Comparison	Metals in Surface Soil
Table A-16	Background Comparison	Radionuclides in Surface Soil

EXPLANATORY NOTES
BACKGROUND COMPARISON AND 95% UTL TABLES
ROCKY FLATS OU-2

Groundwater Background comparisons for metals and radionuclides in groundwater were done two ways (1) No 1 Sandstone separately and (2) an aggregate of the No 1 Sandstone, Rocky Flats Alluvium, Colluvium, and Valley Fill (Upper Hydrostratigraphic Unit or UHSU) The No 1 Sandstone is the only lithologic unit that can possibly support a water supply well Yields in other units are seasonal and so low that supply would be depleted within days under a typical domestic pumping scenario Therefore, the No 1 Sandstone is the appropriate lithologic unit to evaluate in selecting chemicals of concern for a hypothetical on-site residential groundwater exposure scenario (Total metals and radionuclides were included in this scenario) Combined data from UHSU were used to identify metals and radionuclides for further consideration in selecting chemicals of concern for fate and transport modeling (Dissolved metals and radionuclides were included in this scenario)

There were no background data available for radionuclides for groundwater in the No 1 Sandstone Therefore, combined data from the alluvium and colluvium were used to establish background levels of radionuclides for comparison to OU-2 data

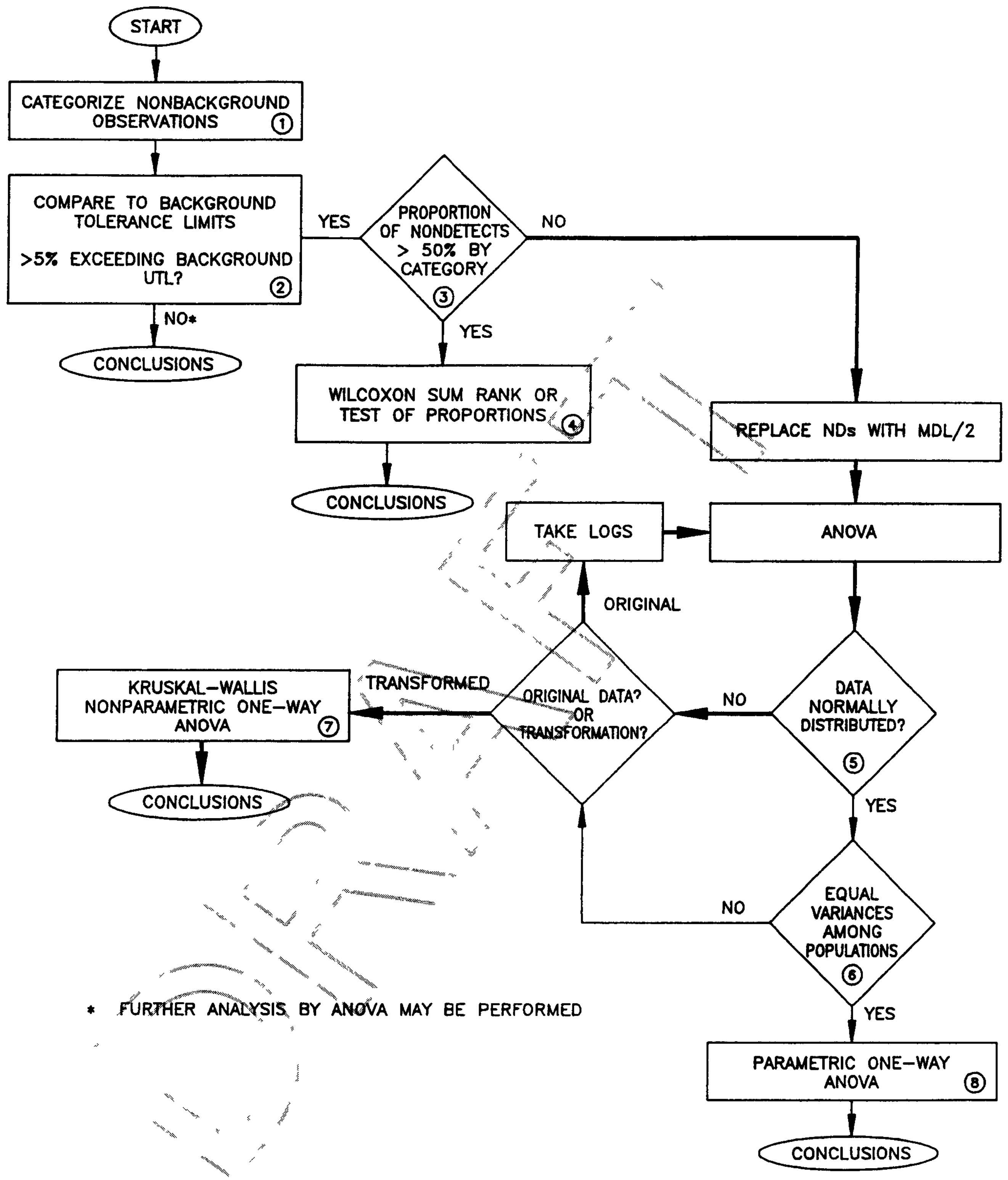
Subsurface Soil OU-2 subsurface soil data used in the background comparison were from borehole samples collected above the water table Soil samples collected below water table were not included in the comparison because of the potential for cross-contamination from groundwater In this way, data from subsurface soil samples are independent of groundwater contaminants

Surface Soil OU-2 surface soil data used in the comparison to background included all data submitted to Woodward-Clyde by June 6, 1993

Comparison to Background UTLs OU-2 data were compared to the 95% UTL of the background data If no more than 5 percent of OU-2 results for a given analyte exceeded the 95th percent UTL of the background data, the analyte can be considered to be within background range Additional evaluation by ANOVA may be performed

ANOVA Comparison Tables "Consider Further" The last column of each ANOVA Comparison Table contains a yes (Y) or no (N) to indicate whether the metal or radionuclide will be considered further in selection of contaminants of concern A "yes" means that the metal or radionuclide appeared to exceed background levels based on the ANOVA analysis (or that there were no site-specific background data available for comparison) OU-2 data were also evaluated by comparing to the 95% UTL of the background data (see above) Final selection of chemicals of concern was made following further evaluation of the data (e g , frequency of detection, concentration/toxicity screens, and spatial distribution.

Use of Non-detect Values in Calculations For metals, the UTL comparison was performed using the detection limit as the concentration for non-detections, the ANOVA was performed using one-half the detection limit for non-detections For radionuclides, non-detections and negative results were not included in the calculation



* FURTHER ANALYSIS BY ANOVA MAY BE PERFORMED

U S DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO 2
PHASE II RFI/RI REPORT

SELECTION OF STATISTICAL METHOD FOR COMPARISON OF BACKGROUND AND NONBACKGROUND POPULATIONS

FIGURE A-1 JULY 1993

RFSSCAL1

TABLE A-1
ROCKY FLATS PLANT OU-2
95% UTL COMPARISON
TOTAL METALS IN GROUNDWATER, µg/L
NO 1 SANDSTONE

	OU-2 Detected			Bknd	Background	% of OU-2 data
Analyte	Min	Max	DF %	Max	95% UTL(1)	> 95% UTL (2)
Aluminum	870	128000	100	7000	8386	71
Antimony	10	297	20	1610	1274	0
Arsenic	1	11	77	7	8	4
Barium	99	3090	100	1810	1451	7
Beryllium	1	19	63	160	126	0
Cadmium	1	11	36	1720	1356	0
Cesium	30	80	9	500	408	24
Chromium	4	209	75	1590	1255	0
Cobalt	3	99	68	1620	1278	0
Copper	4	206	83	1750	1382	0
Cyanide	1	27	44	8	5	21
Lead	1	171	99	15	14	53
Lithium	4	84	93	100	111	0
Manganese	9	4920	100	710	601	31
Mercury	0 25	0 8	15	-	0 2	15
Molybdenum	3	26	49	1600	1263	0
Nickel	4	188	85	1660	1311	0
Selenium	1	6	50	2	3	18
Silver	2	4	13	300	237	0
Strontium	262	1370	99	1110	1114	25
Thallium	1	3	15	2	2	5
Tin	14	87	21	100	92	1
Vanadium	7	345	100	1670	1318	0
Zinc	14	839	98	1800	1442	0

(1) Background Geochemical Characterization Report, Rocky Flats Plant, EG&G, 1992

(2) UTL comparison is performed using the detection limit for results reported as non-detect Therefore, the maximum detected value in OU-2 can be below the 95% UTL of background even though the UTL comparison shows that a certain percentage of OU-2 data exceeds the 95% UTL of background

DF = Detection frequency

TABLE A-2
ROCKY FLATS PLANT OU-2
95% UTL COMPARISON
TOTAL RADIONUCLIDES IN GROUNDWATER, pCi/L
NO 1 SANDSTONE

Analyte	OU-2 Detected Min	Max	DF	Bknd Max	Bknd 95% UTL (1)	% of OU-2 data >95% UTL
Americium-241	0 001	1 09	86/102	0 041	0 053	7
Cesium-137(2)	0 05	1 66	49/91	1 35	1 82	0
Plutonium-239/240	0 0006	5 02	100/106	0 02	0 036	20
Strontium-89/90	0 39	0 39	1/4	-	NE	*
Tritium	ND	-	0/16	555	691 5	0
Uranium-233/234	3 7	8 2	4/4	164	165 4	0
Uranium-235	0 06	0 28	4/4	6 29	10 2	0
Uranium-238	2	6 4	4/4	108	105 5	0

(1) Background Geochemical Characterization Report, Rocky Flats Plant, EG&G 1992
Note No background data for radionuclides in the No 1 Sandstone are available
Background UTLs are calculated using data from the alluvium and colluvium
(2) Includes "total radioactive cesium" (4 analyses)

DF = Detection frequency (no detects/no samples)
NE = not evaluated Data insufficient to calculate 95% UTL
ND = not detected
* Comparison cannot be made

TABLE A-3
ROCKY FLATS PLANT OU-2
95% UTL COMPARISON
DISSOLVED METALS IN GROUNDWATER, µg/L
USHU

	OU-2 Detected			Bknd	Background	% of OU-2 data
Analyte	Min	Max	DF %	Max	95% UTL(1)	>95% UTL (2)
Aluminum	20	367	74	8610	198	1
Antimony	8	88	17	60	53	6
Arsenic	1	8	11	10	8	0
Barium	23	675	100	200	176	37
Beryllium	1	3	4	5	4	0
Cadmium	1	98	11	9	5	1
Cesium	30	120	20	1000	747	0
Chromium	3	23	24	23	13	8
Cobalt	3	13	6	50	37	0
Copper	1	19	25	25	20	0
Lead	1	10	6	64	5	1
Lithium	2	127	79	250	113	1
Manganese	1	3940	73	180	27	46
Mercury	0 21	0 32	3	1 2	0 64	0
Molybdenum	2	67	45	100	64	1
Nickel	2	1210	31	40	30	6
Selenium	1	168	36	173	5	5
Silver	2	25	9	12	10	1
Strontium	240	3040	99	1710	1041	6
Thallium	1	2	6	328	9	0
Tin	12	89	10	8830	76	2
Vanadium	3	12	69	50	36	0
Zinc	1	759	67	129	40	4

(1) Background Geochemical Characterization Report, Rocky Flats Plant, EG&G 1992
(2) UTL comparison is performed using the detection limit for results reported as non-detect Therefore, the maximum detected value in OU-2 can be below the 95% UTL of background even though the UTL comparison shows that a certain percentage of OU-2 data exceeds the 95% UTL of background

DF = Detection frequency

TABLE A-4
ROCKY FLATS PLANT OU-2
95% UTL COMPARISON
DISSOLVED RADIONUCLIDES IN GROUNDWATER, pCi/L
UHSU

Analyte	OU-2 Detected Min	OU-2 Detected Max	OU-2 Detected DF	Bknd Max	Bknd 95% UTL (1)	% OU2 data > 95% UTL
Americium-241	0 001	21 3	10/10	--	NE	*
Cesium-137(2)	0 25	1 5	9/29	--	NE	*
Plutonium-239/240	0 0003	0 81	10/13	--	NE	*
Radium-226	0 12	2 82	53/54	0 43	0 86	9 3
Strontium-89/90	0 09	2 14	167/198	--	NE	*
Tritium	0 96	1753	183/218	761	NE	*
Uranium-233/234	0 18	42 62	233/233	199 5	142 0	0
Uranium-235	0 03	1 5	182/233	4 8	9 3	0
Uranium-238	0 17	75 73	227/227	135 6	116 0	0

(1) Background Geochemical Characterization Report, Rocky Flats Plant, EG&G 1992
Note No background data for radionuclides in the No 1 Sandstone are available
Background UTLs are calculated using data from the alluvium and colluvium
(2) Includes "total radioactive cesium" (15 analyses)

DF = Detection frequency (no. detects/no samples)
NE = not evaluated Data insufficient to calculate 95% UTL
* Comparison cannot be made

TABLE A-5
ROCKY FLATS PLANT OU-2
95% UTL COMPARISON
METALS IN SUBSURFACE SOIL, mg/kg

Note An error has been noted in the background data that is likely to affect the results of the background comparison The error is being corrected and new results will be provided in the revised draft of this document

	OU-2 Detected			Bknd	Background	% of OU-2 data
Analyte	Min	Max	DF %	Max	95% UTL(1)	> 95% UTL (2)
Aluminum	1190	70,600	100	40,800	1,292,079	0
Antimony	4	24	4	11,900	2,141	0
Arsenic	0	37	94	42	12	13
Barium	10	1899	83	544	9,815	0
Beryllium	0	23	47	1,640	297	0
Cadmium	1	10	45	990	178	0
Cesium	1	5	91	198,000	35,629	0
Chromium	2	127	98	12,300	2,213	0
Cobalt	1	78	55	9,900	1,782	0
Copper	3	132	84	8,590	1,547	0
Lead	1	86	99	30	25	2
Lithium	1	25	91	5,820	1,053	0
Manganese	4	1610	100	233,000	41,850	0
Mercury	0	114	20	0 64	0 35	1 3
Molybdenum	1	19	33	4,730	859	0
Nickel	4	63	79	13,500	2,432	0
Selenium	0	2	7	12	7	0
Silver	1	96	13	1,980	358	0
Strontium	4	246	82	19,800	3,617	0
Thallium	0	1	12	5	3	0
Tin	22	56	24	19,800	3,588	0
Vanadium	4	61	97	20,000	3,602	0
Zinc	4	437	98	34,000	6,116	0

(1) Background Geochemical Characterization Report, Rocky Flats Plant, EG&G 1992
(2) UTL Comparison is performed using the detection limit for results reported as non-detect Therefore, the maximum detected value in OU-2 can be below the 95% UTL of background even though the UTL comparison shows that a certain percentage of OU-2 data exceeds the 95% UTL of background

DF = Detection frequency

TABLE A-6
ROCKY FLATS PLANT OU-2
95% UTL COMPARISON
RADIONUCLIDES IN SUBSURFACE SOIL, pCi/g

	OU-2 Detected			Bknd	Bknd 95%	% of OU-2 data
Analyte	Min	Max	DF %	Max	UTL (1)	>95% UTL
Americium-241	0	25	83	-	NE	*
Cesium-134	ND		-	-	NE	
Cesium-137	0	2 4	66	-	0 2	50
Plutonium-239	0	10	100	-	NE	*
Plutonium-239/240	0	68	85	-	NE	*
Radium-226	0	1 9	90	1 3	1 3	4 1
Radium-228	0	2 6	100	2 2	2 0	9
Strontium-89/90	0 002	0 8	70	1 2	1 9	0
Strontium-90	0 01	0 9	98	-	NE	(2)
Tritium (pCi/L)	10	1500	73	440	402 1	10
Uranium-233/234	0 04	192	100	8 9	2 6	2
Uranium-235	0	11 5	88	0 3	0 6	1 7
Uranium-235/236	0 02	0 21	100	-	NE	(3)
Uranium-238	0 09	113	100	3 2	1 51	4 1

(1) Background Geochemical Characterization Report, Rocky Flats Plant, EG&G, 1992
(2) None of the Strontium-90 data points exceeds the 95% UTL concentration for Strontium-89/90
(3) None of the Uranium-235/236 data points exceeds the 95% UTL concentration for Uranium-235

DF = Detection frequency
ND = not detected
NE = not evaluated Data insufficient to calculate 95% UTL
* Comparison cannot be made

TABLE A-7
ROCKY FLATS PLANT OU-2
95% UTL COMPARISON
METALS IN SURFACE SOIL, mg/kg
PRELIMINARY (See Note)

	OU-2 Detected			Bknd	Bknd 95%	% of OU-2 data
Analyte	Min	Max	DF	Max	UTL (1)	>95% UTL(2)
Aluminum	8170	16200	9/9	21800	27348	0
Antimony	ND		0/9	11	10.95	-
Arsenic	3 2	6 1	9/9	8 7	10 97	0
Barium	88 3	167	9/9	324	406 13	0
Beryllium	ND		0/9	1 1	1 32	-
Cadmium	ND		0/9	1	1 08	-
Cesium	ND		0/9	3	3 26	-
Chromium	9 2	15 5	9/9	22	26 4	0
Cobalt	4 6	8 1	9/9	11	11 77	0
Copper	9 9	13 8	9/9	22	24 37	0
Lead	2	48	9/9	44	49 39	0
Lithium	5 3	15 1	9/9	17	19 58	0
Manganese	192	354	9/9	734	769 23	0
Mercury	ND		0/9	0 08	0 085	-
Molybdenum	ND		0/9	2 8	3 32	-
Nickel	9 7	15 3	9/9	19	22 25	0
Selenium	<1	0 47	1/9	0 67	0 9	0
Silver	ND		0/9	1 4	1 4	-
Strontium	22 4	66 3	9/9	109	103 7	0
Thallium	0 5	0 5	2/9	0 41	0 44	0
Tin	24	34 3	3/9	58	66 92	0
Vanadium	23 7	33 5	9/9	46	53 19	0
Zinc	38 7	75 8	9/9	90	109 49	0

Note Approximately 20 percent of surface soil results for metals were available at the time this technical memorandum was prepared. These results are therefore preliminary Surface soil data will be re-evaluated when all data become available

(1) Background Geochemical Characterization Report, Rocky Flats Plant EG&G, 1992

(2) UTL comparison is performed using the detection limit for results reported as non-detect Therefore, the maximum detected value in OU-2 can be below the 95% UTL of background even though the UTL comparison shows that a certain percentage of OU-2 data exceeds the 95% UTL of background

DF = Detection frequency (no detects/no samples)

ND = not detected

TABLE A-8
ROCKY FLATS PLANT OU-2
95% UTL COMPARISON
RADIONUCLIDES IN SURFACE SOIL, pCi/g
PRELIMINARY (See Note)

	OU-2 Detected			Bknd	Bknd 95%	% of OU-2 data
Analyte	Min	Max	DF	Max	UTL (1)	>95% UTL
Americium-241	0 01	110	42/42	0 04	0 052	93
Cesium-134	ND		0/21		NE	*
Cesium-137	0 16	1 6	24/25	1 6	2 07	0
Plutonium-239/240	0 04	11000	51/51	0 08	0 09	95
Radium-226	0 71	11 8	25/25	1 1	1 54	5
Radium-228	1 1	2 9	25/25	2 9	4 53	0
Strontium-89/90	0 02	3 5	25/25	0 8	1 99	5

(1) Background Geochemical Characterization Report, Rocky Flats Plant, EG&G, 1992

DF = Detection frequency (no detects/no samples)
NE = Not evaluated Data insufficient to calculate 95% UTL
ND = Not detected
* Comparison cannot be made

Note Not all surface soil data for radionuclides were available at the time this technical memorandum was prepared These results are therefore preliminary Surface soil data will be re-evaluated when all data become available

TABLE A-9
ROCKY FLATS PLANT OU-2
ANOVA COMPARISON
TOTAL METALS IN GROUNDWATER, µg/L
NO. 1 SANDSTONE

	Background		OU-2 Data								
Analyte	Mean	SD	Mean	SD	Norm Dist?	Test	Result (Chi-Square)	P =	Significantly Different?	BKG Mean >OU2 Mean[1]	Consider Further?
Aluminum	1755	2585	20245	26803	No	Kruskal	26.54	<0 01	Y	N	Y
Antimony	140	442	48	166	No	Kruskal	6 27	0 01	Y	Y	N
Arsenic	3	2	4	2	No	Kruskal	0 342	0 6	N	N	N
Barium	230	476	462	521	No	Kruskal	23 17	<0 01	Y	N	Y
Beryllium	13	44	4	17	No	Kruskal	12 94	<0 01	Y	Y	N
Cadmium	134	477	22	182	No	Kruskal	10 06	<0 01	Y	Y	N
Cesium	82	127	355	190	No	Kruskal	28 63	<0 01	N	N	N
Chromium	130	439	44	165	No	Kruskal	2 69	0 10	N	Y	N
Cobalt	128	448	34	166	No	Kruskal	13.59	<0 01	Y	Y	N
Copper	144	483	48	182	No	Kruskal	5 00	0 03	Y	Y	N
Cyanide	2	1	5	4	No	Kruskal	41 43	<0 01	Y	N	Y
Lead	4	4	23	30	No	Kruskal	19 17	<0 01	Y	N	Y
Lithium	41	27	25	21	No	Kruskal	5.89	0 02	Y	Y	N
Manganese	98	196	569	853	No	Kruskal	19 82	<0 01	Y	N	Y
Mercury	ND	-	0 14	0 13	No	Kruskal	21 64	<0 01	Y	N	Y
Molybdenum	130	442	52	168	No	Kruskal	6 17	0 01	Y	Y	N
Nickel	138	457	47	172	No	Kruskal	3 78	0 05	N	Y	N
Selenium	2	0 44	2	1	No	Kruskal	4.83	0 3	N	N	N

TABLE A-9
(Concluded)

Analyte	Background Mean	Background SD	OU-2 Data Mean	OU-2 Data SD	Norm Dist?	Test	Result (Chi-Square)	P =	Significantly Different?	BKG Mean >OU2 Mean[1]	Consider Further?
Silver	26	82	7	33	No	Kruskal	4.64	0.03	Y	Y	N
Strontium	366	292	516	224	No	Kruskal	10.09	<0.01	Y	N	Y
Thallium	1	0.39	4	2	No	Kruskal	21.43	<0.01	Y	N	Y
Tin	27	25	66	40	No	Kruskal	12.44	<0.01	Y	N	Y
Vanadium	135	461	70	181	No	Kruskal	18.96	<0.01	Y	Y	N
Zinc	193	487	143	225	No	Kruskal	4.08	0.04	Y	Y	N

[1] If the background mean is higher than OU-2 mean, a statistically significant difference ($P<0.05$) is not applicable
ND - non-detection
-- No data

TABLE A-10
ROCKY FLATS PLANT OU-2
ANOVA COMPARISON
TOTAL RADIONUCLIDES IN GROUNDWATER, pCi/L
NO. 1 SANDSTONE

Analyte	Background(1) Mean	Background(1) SD	OU-2 Data Mean	OU-2 Data SD	Norm Dist?	Test	Result (Chi-Square)	P =	Significantly Different?	BKG Mean > OU2 Mean(2)	Consider Further?
Americium 241	0.01	0.01	0.03	0.14	No	Kruskal	1.62	0.20	N	N	N
Cesium 137	0.85	0.31	0.26	0.36	No	Kruskal	13.93	<0.01	Y	Y	N
Plutonium 239, 240	0.01	0.001	0.13	0.57	No	Kruskal	0.05	0.82	N	N	N
Strontium 89,90	--	--	0.18	0.15	No	Kruskal	--	--	--	--	Y
Tritium	431	69	105	92	No	Kruskal	11.08	<0.01	Y	Y	N
Uranium 233, 234	26	54	5	2	No	Kruskal	0.46	0.50	N	Y	N
Uranium 235	2	2	0.16	0.12	No	Kruskal	5.53	0.02	Y	Y	N
Uranium 238	13	34	3	2	No	Kruskal	1.28	0.26	N	Y	N

(1) No background data for radionuclides in the No 1 Sandstone are available in the Background Geochemical Characterization Report (EG&G 1992) Data from the alluvium and colluvium are used in this analysis.

(2) If the background mean is higher than OU-2 data mean, a statistically significant difference ($P < 0.05$) is not applicable

-- No data

TABLE A-11
ROCKY FLATS PLANT OU-2
ANOVA COMPARISON
DISSOLVED METALS IN GROUNDWATER, µg/L
UHSU

Analyte	Background Mean	Background SD	OU-2 Data Mean	OU-2 Data SD	Norm Dist?	Test	Result (Chi-Square)	P =	Significantly Different?	BKG Mean ≥OU2 Mean[1]	Consider Further?
Aluminum	61	63	57	46	No	Kruskal	1.63	0.20	N	Y	N
Antimony	19.36	15	25	12	No	Kruskal	19.98	<0.01	Y	N	Y
Arsenic	3	2	4	2	No	Kruskal	10.86	<0.01	Y	N	Y
Barium	93	38	150	75	No	Kruskal	44.93	<0.01	Y	N	Y
Beryllium	1	1	2	1	No	Kruskal	17.73	<0.01	Y	N	Y
Cadmium	3	1	3	7	No	Kruskal	1.61	0.21	N	Y	N
Cesium	221	247	329	197	No	Kruskal	15.09	<0.010	Y	N	Y
Chromium	6	3	5	4	No	Kruskal	1.75	0.19	N	Y	N
Cobalt	8	14	17	11	No	Kruskal	18.57	<0.01	Y	N	Y
Copper	7	6	8	5	No	Kruskal	7.11	<0.01	Y	N	Y
Lead	2	2	1	1	No	Kruskal	11.81	<0.01	Y	Y	N
Lithium	44	32	20	27	No	Kruskal	35.74	<0.01	Y	Y	N
Manganese	10	8	181	494	No	Kruskal	12.48	<0.01	Y	N	Y
Mercury	0.23	0.19	0.11	0.09	No	Kruskal	107.21	<0.01	Y	Y	N
Molybdenum	15	22	38	43	No	Kruskal	11.02	<0.01	Y	N	Y
Nickel	8	10	27	98	No	Kruskal	45.39	<0.01	Y	N	Y
Selenium	2	1	5	19	No	Kruskal	6.66	<0.01	Y	N	Y
Silver	4	3	4	2	No	Kruskal	3.36	0.07	N	Y	N

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TABLE A-11
(Concluded)

Analyte	Background Mean	Background SD	OU-2 Data Mean	OU-2 Data SD	Norm Dist?	Test	Result (Chi-Square)	P =	Significantly Different?	BKG Mean ≥OU2 Mean[1]	Consider Further?
Strontium	394	296	537	397	No	Kruskal	24 90	<0 01	Y	N	Y
Thallium	3	3	4	2	No	Kruskal	13.92	<0 01	Y	N	Y
Tin	24	24	66	42	No	Kruskal	29 39	<0 01	Y	N	Y
Vanadium	8	13	8	8	No	Kruskal	1 27	0 26	N	Y	N
Zinc	12	13	16	53	No	Kruskal	0 67	0 41	N	N	N

[1] If the background mean is equal to or higher than OU-2 data mean, a statistically significant difference (P<0 05) is not applicable

-- no data

TABLE A-12
ROCKY FLATS PLANT OU-2
ANOVA COMPARISON
DISSOLVED RADIONUCLIDES IN GROUNDWATER, pCi/L
UHSU

	Background(1)		OU-2 Data								
Analyte	Mean	SD	Mean	SD	Norm Dist?	Test	Result (Chi-Square)	P =	Significantly Different?	BKG Mean >OU2 Mean(2)	Consider Further?
Americium 241	–	–	2	7	No	Kruskal	–	–	–	–	Y
Cesium 137(4)	–	–	0.53	0.56	No	Kruskal	–	–	–	–	Y
Plutonium 239, 240	–	–	0 08	0 22	No	Kruskal	–	–	–	–	Y
Radium 226	0 24	0 14	1	0 39	No	Kruskal	5.58	0 02	Y	N	Y
Strontium 89 90	–	–	0 37	0 33	No	Kruskal	–	–	–	–	Y
Tritium	760 9(3)	–	146	169	No	Kruskal	2 93	0 09	N	–	N
Uranium 233, 234	24	53	5	5	No	Kruskal	0 67	0 41	N	Y	N
Uranium 235	2	2	0 15	0 20	No	Kruskal	16 48	<0 01	Y	Y	N
Uranium 238	21	40.5	3 60	7	No	Kruskal	0.63	0 43	N	Y	N

(1) No background data for radionuclides in the No 1 Sandstone are available in the Background Geochemical Characterization Report (EG&G 1992) Background data from the alluvium and the colluvium are used in this analysis
(2) If the background mean is higher than OU-2 data mean, a statistically significant difference (P<0 05) is not applicable
(3) One background data point
(4) Includes "total radioactive cesium" analyses
– No data

TABLE A-13
ROCKY FLATS PLANT OU-2
ANOVA COMPARISON
METALS IN SUBSURFACE SOIL, mg/kg
VADOSE ZONE

Note An error has been noted in the background data that is likely to affect the results of the background comparison The error is being corrected and new results will be provided in the revised draft of this document

	Background		OU-2 Data								
Analyte	Mean	SD	Mean	SD	Norm Dist?	Test	Result (Chi-Square)	P =	Significantly Different?	BKG Mean >OU2 Mean[1]	Consider Further?
Aluminum	77529	692153	10614	5871	No	Kruskal	0 62	0 43	N	Y	N
Antimony	124	1149	10	3	No	Kruskal	175 87	<0 01	Y	Y	N
Arsenic	4	4	6	5	No	Kruskal	37 94	<0 01	Y	N	Y
Barium	602	5250	88	126	No	Kruskal	11.57	<0 01	Y	Y	N
Beryllium	20	158	0 99	1	No	Kruskal	223.55	<0.01	Y	Y	N
Cadmium	10	96	1	1	No	Kruskal	6 27	0 01	Y	Y	N
Cesium	2080	19119	21	74	No	Kruskal	160 46	<0 01	Y	Y	N
Chromium	129	1188	13	11	No	Kruskal	5.54	0 02	Y	Y	N
Cobalt	104	956	8	5	No	Kruskal	154 21	<0 01	Y	Y	N
Copper	92	829	10	9	No	Kruskal	16 38	<0.01	Y	Y	N
Lead	12	7	8	8	No	Kruskal	27 64	<0 01	Y	Y	N
Lithium	68	561	8	4	No	Kruskal	15.84	<0 01	Y	Y	N
Manganese	2354	22508	187	176	No	Kruskal	0 003	0 96	N	Y	N
Mercury	0 16	0 11	0 49	7	No	Kruskal	108 06	<0 01	Y	N	Y
Molybdenum	59	456	2	2	No	Kruskal	156.28	<0 01	Y	Y	N
Nickel	145	1303	13	6	No	Kruskal	38.90	<0 01	Y	Y	N

TABLE A-13
(Concluded)

Analyte	Background		OU-2 Data								
	Mean	SD	Mean	SD	Norm Dist?	Test	Result (Chi-Square)	P =	Significantly Different?	BKG Mean >OU2 Mean[1]	Consider Further?
Selenium	3	2	0.68	0.38	No	Kruskal	173.13	<0.01	Y	Y	N
Silver	22	191	2	7	No	Kruskal	206.12	<0.01	Y	Y	N
Strontium	269	1908	42	39	No	Kruskal	44.86	<0.01	Y	Y	N
Thallium	2	0.61	1	0.87	No	Kruskal	168.77	<0.01	Y	Y	N
Tin	234	1911	29	10	No	Kruskal	2.78	0.09	N	Y	N
Vanadium	214	1931	24	10	No	Kruskal	2.89	0.08	N	Y	N
Zinc	355	3283	30	32	No	Kruskal	9.68	<0.01	Y	Y	N

[1] If the background mean is higher than OU-2 data mean, a statistically significant difference ($P < 0.05$) is not applicable

– no data

TABLE A-14
ROCKY FLATS PLANT OU-2
ANOVA COMPARISON
RADIONUCLIDES IN SUBSURFACE SOIL, pCi/g
VADOSE ZONE

	Background		OU-2 Data								
Analyte	Mean	SD	Mean	SD	Norm Dist?	Test	Result (Chi-Square)	P =	Significantly Different?	BKG Mean >OU2 Mean[1]	Consider Further?
Americium 241	–	–	0.44	2 41	No	Kruskal	–	–	–	–	Y
Cesium 137	–[2]	–	0.71	0 72	No	Kruskal	0 00	1 00	–	–	Y
Plutonium 239	–	–	0.009	0 006	No	Kruskal	–	–	–	–	Y
Plutonium 239, 240	–	–	1 94	8 14	No	Kruskal	–	–	–	–	Y
Radium 226	0 79	0 25	0 61	0 27	No	Kruskal	33.30	<0 01	Y	Y	N
Radium 228	1 38	0 31	1 40	0 44	No	Kruskal	0.76	0 78	N	Y	N
Strontium 89,90	0 88	0 22	0 23	0 17	No	Kruskal	11 37	<0 01	Y	Y	N
Strontium 90	–	–	0 14	0 13	No	Kruskal	–	–	–	–	N[3]
Tritium (pCi/L)	243 45	72 32	196 74	145 01	No	Kruskal	9 27	<0 01	Y	Y	N
Uranium 233, 234	0 83	0 92	2 13	15 68	No	Kruskal	2 99	0 08	N	N	N
Uranium 235	0 23	0 06	0 15	1 06	No	Kruskal	8 13	<0 01	Y	Y	N
Uranium 235, 236	–	–	0 06	0 06	No	Kruskal	–	–	–	–	N[4]
Uranium 238	0 76	0 39	1 80	9 45	No	Kruskal	10 46	<0 01	Y	N	Y

[1] If the background mean is higher than OU-2 data mean, a statistically significant difference ($P<0.05$) is not applicable

[2] One background data point

[3] Mean concentration of Strontium 90 is lower than background mean for Strontium 89,90 Therefore Strontium 90 is not considered further

[4] Mean concentration of Uranium 235,236 is lower than background mean for Uranium 235 Therefore, Uranium 235,236 is not considered further

TABLE A-15
ROCKY FLATS PLANT OU-2
ANOVA COMPARISON
METALS IN SURFACE SOIL, mg/kg
PRELIMINARY (See Note)

	Background		OU2 Data								
Analyte	Mean	SD	Mean	SD	Norm Dist?	Test	Result (Chi-Square)	P =	Significantly Different?	BKG Mean >OU2 Mean[1]	Consider Further?
Aluminum	12900	5515	10661	2608	No	Kruskal	4 23	0 04	Y	Y	N
Arsenic	6	2	5	1	No	Kruskal	1 41	0 24	N	Y	N
Barium	187	84	109	17	No	Kruskal	12 99	<0 01	Y	Y	N
Chromium	16	4	12	2	Yes	K-S	10 89[2]	<0 01	Y	Y	N
Cobalt	7	2	6	1	No	Kruskal	4 24	0 04	Y	Y	N
Copper	16	3	12	1	No	Kruskal	12 74	<0 01	Y	Y	N
Lead	36	5	26.5	12	No	Kruskal	3 68	0 05	N	Y	N
Lithium	12	3	10	2	No	Kruskal	6 64	0 01	Y	Y	N
Manganese	324	170	248	54	No	Kruskal	6 11	0 01	Y	Y	N
Nickel	14	3	12	2	No	Kruskal	3 45	0 06	N	Y	N
Selenium	0 45	0 17	0 46	0 02	No	Kruskal	0 04	0 84	N	N	N
Strontium	42	24	41	15	No	Kruskal	0 17	0 68	N	Y	N
Thallium	0 28	0 06	0 47	0 02	Yes	K-S	106 97[2]	<0.01	Y	N	Y
Tin	42	9	23	1	No	Kruskal	17.87	<0 01	Y	Y	N
Vanadium	33	8	28	4	No	Kruskal	1 89	0 17	N	Y	N
Zinc	57	20 14	49	6	No	Kruskal	6 64	0 01	Y	Y	N

[1] If the background mean is higher than OU2 data mean, a statistically significant difference ($P<0\ 05$) is not applicable
[2] K-S comparison is used on normally distributed data

Note Data set includes all data received by 6/2/93 Comparison to background may be reevaluated when all analytical results are available

(4034-263-0049-540)(R7T.A23)(07 18-93)(6:20pm)

TABLE A-16
ROCKY FLATS PLANT OU-2
ANOVA COMPARISON
RADIONUCLIDES IN SURFACE SOIL, pCi/g
PRELIMINARY (See Note)

Analyte	Background Mean	Background SD	OU-2 Data Mean	OU-2 Data SD	Norm Dist?	Test	Result (Chi-Square)	P =	Significantly Different?	BKG Mean >OU2 Mean[1]	Consider Further?
Americium 241	0.023	0.0098	13.08	23.91	No	Kruskal	17.93	<0.01	Y	N	Y
Cesium 137	1.28	0.23	0.86	0.46	No	Kruskal	–[2]	–	–	Y	N
Plutonium 239, 240	0.048	0.015	484.9	1609.4	No	Kruskal	32.54	<0.01	Y	N	Y
Radium 226	1.00	0.12	1.57	2.41	No	Kruskal	0.036	0.85	N	N	N
Radium 228	2.28	0.51	1.94	0.42	No	Kruskal	–[2]	–	–	Y	N
Strontium 89,90	0.63	0.22	0.69	0.71	No	Kruskal	0.34	0.56	N	N	N

1 If the background mean is higher than OU-2 data mean, a statistically significant difference ($P < 0.05$) is not applicable
2 Chi-square tests were not performed for Cesium 137 and Radium 228 because 5% of the data did not exceed the 95% UTL of background and OU-2 mean was lower than background mean These radionuclides are not considered to exceed background levels

Note All analytical results for surface soil samples have not been received as of 6/2/93 Comparison to background may be reevaluated when all analytical results are available

APPENDIX B

APPENDIX B
RISK-BASED EVALUATION OF LOW FREQUENCY CHEMICALS

B.1 PURPOSE AND APPROACH

The chemicals of concern evaluated in a quantitative human health risk assessment are the subset of all chemicals found on-site that are thought to pose the greatest potential risk to human health The determination that these chemicals may pose the greatest potential risk is generally based on an evaluation of the following three criteria

- The inherent toxicity of the chemical,
- The concentrations of the chemical found on-site, and
- The potential for human exposure to the chemical (e g , whether or not the chemical is widely distributed across the site)

In general, compounds found at low frequency (<5% of all samples) are not included as chemicals of concern because the potential for human exposure is limited However, all low-frequency compounds were evaluated according to the procedures shown in Figure 2-1 so as not to neglect infrequently detected chemicals that could contribute significantly to risk if they were co-located with other potentially hazardous compounds at source areas or at locations where routine exposure could occur

This evaluation examines those organic chemicals that were initially excluded from the chemicals of concern based on low frequency of detection, using a health-based screening approach A screening evaluation was performed for all low-frequency chemicals for which toxicity values were available As a benchmark, it was assumed that any low-frequency chemical whose maximum concentration was greater than 1000 times a risk-based concentration (RBC) based on a target hazard index (HI) of 1 0 or target cancer risk of 10^{-6} (1,000,000) warrants further evaluation The purpose is to identify those low-frequency chemicals that may pose an unacceptable health risk (cancer or non-cancer) if chronic exposure were to occur These chemicals are retained for separate evaluation in the risk assessment as "special case" chemicals of concern Since they are not characteristic of contamination in OU-2, risk will be assessed separately at the locations where the special case low frequency chemicals are found

RBCs were calculated assuming a residential exposure scenario, using site-specific exposure assumptions, and using standard toxicity values (RfDs and SFs) supplied by EPA For surface soils and subsurface soils, multiple pathway exposure was assumed (ingestion, dermal contact, and inhalation of particulates) in calculating RBCs Exposure was evaluated for ingestion only for groundwater, since this was assumed to be the only major groundwater exposure route The parameters used to evaluate potential exposure (and to calculate intake factors) are presented in Tables B-1 through B-4 These parameters were presented in the Exposure Assessment Technical Memorandum No 5 (DOE 1993) Toxicity values were derived from IRIS (1993) and HEAST (1991 and 1992), and are summarized in Tables 2-3 and 2-4 RBCs were then multiplied by 1000 to generate the screening concentrations for use in the evaluation

Note on dermal absorption of organics from soil:

The absorbed fraction (AB in Table B-3) is the estimated fraction of organic compounds adhered to soil particles that partitions to and is absorbed through skin Percent absorbed depends upon soil loading, organic carbon content of soil, contaminant concentration, duration of exposure, animal species used in the experiment, and whether the experiment is conducted in vitro or in vivo For purposes of this risk assessment, an upperbound estimate of absorption rate for organic compounds adhered to soil particles is assumed to be 10 percent These rates are based on experimental results using B(a)P in acetone or in crude oil, and adjusting the absorption rates for shorter exposure duration and the observed retarding effect of the soil medium[1] The experimental results are summarized in Table B-5, Percent Dermal Absorption of Neat Benzo(a)pyrene at 24 hours Absorption rates range from 3 to 51 percent at 24 hours The arithmetic mean absorption rate is 17 percent, and the 95 percent UCL on the mean rate is 26 percent To adjust these experimental rates to account for site-specific exposure conditions, it is assumed that the exposed individual showers within 12 hours of exposure, and that absorption from soil is one-fifth that of the pure compound (Yang et al 1989, Wester et al 1990) Therefore, the 24-hour absorption rates of heat B(a)P are adjusted by a factor of 0 5 for a 12-hour exposure and 0 2 for the soil matrix effect Resulting absorption rates are

17 x 0 5 x 0 2 = 1 7 percent

1 In recent guidance on dermal exposure assessments (EPA 1992b), EPA has declined to recommend an absorption rate for B(a)P is soil because of the variability in experimental conditions and results and the difficulty in extrapolating from high soil loadings (e g , tens of mg/cm^2) under experimental conditions to lower loading (e g , 1 mg/cm^2) typical of human exposures (EPA 1992b) (B(a)P at concentrations of 1 and 10 mg/kg and soil loadings of 40 to 56 mg/cm$_2$, experimental results for percent absorbed at 24 hours ranges from 1 percent [Yang et al 1989] to 13 percent [Wester et al 1990])

It should be noted that B(a)P is one of the more lipophilic of the polycyclic aromatic hydrocarbons, and therefore it may be absorbed at a higher rate than a number of other organic chemicals of concern Also, the use of dermal absorption values obtained in experimental animal studies will almost always result in a conservative (i e, higher) estimate of dermal absorbed dose in humans (EPA 1992b) Therefore, the dermal absorption rate used in this analyses (10 percent) is concluded to be a reasonable conservative estimate of a reasonable maximum rate of dermal absorption of organic compounds from soil

B.2 GROUNDWATER

Twenty-six VOCs and SVOCs were reported at low frequency (<5% detection) in groundwater samples Table B-6 presents a comparison of the maximum detected concentrations to the health-based screening criteria (both cancer and non-cancer) and presents the equations used to develop the screening concentrations Chemicals whose maximum detected concentration was greater than 1000 times either the cancer or non-cancer RBCs were retained for further evaluation as potential chemicals of concern Based on the comparison to screening-level concentrations, two chemicals, 1,2-dibromoethane, and vinyl chloride, were identified as requiring further evaluation in the human health risk assessment as potential chemicals of concern (see Section 3 5)

B.3 SOIL

Organic compounds detected as less than 5 percent frequency in subsurface soil samples and in surface soils are listed in Tables B-7 and B-8 Table B-6 (carcinogenic effects) presents a comparison of the maximum detected concentrations in subsurface and surface soils to the health-based screening criteria (carcinogens) and presents the equations used to develop the screening concentrations Table B-7 presents a similar comparison for non-carcinogenic effects

As with groundwater, chemicals whose maximum detected concentration was greater than 1000 times either the cancer or non-cancer risk-based screening concentration were retained further evaluation as potential chemicals of concern Based on this evaluation, no low frequency chemicals found in surface or subsurface soils failed the screening evaluation (e g, no low frequency chemicals in soils were identified as potential chemicals of concern)

TABLE B-1
ROCKY FLATS PLANT OU-2
UHSU GROUNDWATER INGESTION
HYPOTHETICAL FUTURE ON-SITE RESIDENT

$$\text{Intake Factor} = \frac{IR \times EF \times ED \times FI}{BW \times AT}$$

	Parameter	RME
IR	Intake rate (l/day)[1]	2 0
EF	Exposure frequency (days/year)[1]	350
ED	Exposure duration (years)[1]	30
FI	Fraction ingested from contaminated source	1 0
BW	Body weight (kg)	70
AT	Averaging time (days)	
	Noncarcinogenic	10,950
	Carcinogenic	25,550
IF	Intake Factor (L/kg-day)	
	Noncarcinogenic	0 027
	Carcinogenic	0 0117

(1) Source EPA 1991b

TABLE B-2
ROCKY FLATS PLANT OU-2
SOIL INGESTION
CURRENT OFF-SITE RESIDENT (ADULT AND CHILD)[1]

Noncarcinogenic

$$\text{Intake Factor} = \left[\frac{(200\ \text{mg/day} \times 350\ \text{day/yr} \times 6\ \text{yr})}{15\ \text{kg} \times 365\ \text{day/yr}} + \frac{(100\ \text{mg/day} \times 350\ \text{day/yr} \times 24\ \text{yr})}{70\ \text{kg} \times 365\ \text{day/yr}}\right] \times 0\ 5 \times 10^{-6}\ \text{kg/mg/30 yr}$$

Carcinogenic

$$\text{Intake Factor} = \left[\frac{(200\ \text{mg/day} \times 350\ \text{day/yr} \times 6\ \text{yr})}{15\ \text{kg} \times 365\ \text{day/yr}} + \frac{(100\ \text{mg/day} \times 350\ \text{day/yr} \times 24\ \text{yr})}{70\ \text{kg} \times 365\ \text{day/yr}}\right] \times 0\ 5 \times 10^{-6}\ \text{kg/mg/70 yr}$$

	Parameter	RME Adult	RME Child
IR	Ingestion rate (mg/day)[1]	100	200
FI	Fraction ingested from contaminated source[2]	0 5	0 5
ME	Matrix effect[3]	1 0	
EF	Exposure frequency (days/year)[4]	350	350
ED	Exposure duration (years)[5]	24	6
CF	Conversion factor (kg/mg)	10^{-6}	10^{-6}
BW	Body weight (kg)	70	15
AT	Averaging time (days)		
	Noncarcinogenic	10,950	
	Carcinogenic	25,550	
IF	Intake Factor (kg/kg-day)		
	Noncarcinogenic	$1\ 8 \times 10^{-6}$	
	Carcinogenic	$7\ 8 \times 10^{7}$	

(1) The calculation of a 30-year residential exposure to soil is divided into two parts First, a six-year exposure duration is evaluated for young children, and this accounts for the period of highest soil ingestion (200 mg/day) and lowest body weight (15 kg) Second, a 24-year exposure duration is assessed for older children and adults by using a lower soil ingestion rate (100 mg/day) and an adult body weight (70 kg) (EPA 1991b)

(2) The FI assumes that 50 percent of the soil ingested daily in from the contaminated source

(3) The matrix effect describes the reduced availability due to adsorption of chemicals to soil or food compared to the same dose administered orally in solution Therefore, the soil matrix has the effect of reducing the intake of the compound A matrix effect of 1 0 (100 percent absorption) is used unless as a conservative value for screening purposes

TABLE B-3
ROCKY FLATS PLANT OU-2
DERMAL CONTACT WITH SURFACE SOIL
CURRENT OFF-SITE RESIDENT

$$\text{Intake Factor} = \frac{SA \times AB \times AF \times FC \times EF \times ED \times CF}{BW \times AT}$$

	Parameter	RME
SA	Surface area (cm^2)[1]	2,910
AB	Absorption factor[2]	0 1
AF	Adherence factor (mg/cm^2)[3]	0 5
FC	Fraction contacted from contaminated source[4]	0 5
EF	Exposure frequency (days/year)[5]	350
ED	Exposure duration (years)[6]	30
CF	Conversion factor (kg/mg)	10^{-6}
BW	Body weight (kg)	70
AT	Averaging time (days)	
	Noncarcinogenic	10,950
	Carcinogenic	25,550
IF	Intake Factor (kg/kg-day)	
	Noncarcinogenic	$1\ 0 \times 10^{-6}$
	Carcinogenic	$4\ 3 \times 10^{7}$

(1) The surface area is equivalent to face, forearms, and hands, or 15 percent of total body surface (EPA 1989b)

(2) Dermal absorption of metals from a soil matrix is negligible (EPA 1991a) For screening purposes, the absorption factor for semivolatiles, volatiles, and other organics is assumed to be 10 percent (see Table B-8)

(3) Source Sedman 1989

(4) The FC assumes that residents are at home for 16 hours per day and are at work, school, or other locations for 8 hours per day

(5) Assumes that residents take 15 days per year vacation (EPA 1991b)

(6) Source EPA 1991b

TABLE B-4
ROCKY FLATS PLANT OU-2
INHALATION OF PARTICULATES
CURRENT OFF-SITE RESIDENT

$$\text{Intake Factor} = \frac{IR \times ET \times EF \times ED \times DF}{BW \times AT}$$

	Parameter	RME
IR =	Inhalation rate (m^3/hr)(1)	0 83
ET =	Exposure time (hours/day)	24
EF =	Exposure frequency (days/year)(2)	350
ED =	Exposure duration (years)(2)	30
DF =	Deposition factor(3)	0 75
BW =	Body weight (kg)	70
AT =	Averaging time (days)	
	Noncarcinogenic	10,950
	Carcinogenic	25,550
IF	Intake Factor (m^3/kg-day)	
	Noncarcinogenic	$2\ 0 \times 10^{1}$
	Carcinogenic	$8\ 8 \times 10^{2}$

(1) Equivalent to 20 m^3/day (EPA 1991b)
(2) Source EPA 1991b
(3) Seventy-five percent of inhaled particles are deposited and remain in the lung, it is assumed that all chemicals in that fraction are absorbed (Cowherd 1985)

TABLE B-5
ROCKY FLATS PLANT OU-2
PERCENT DERMAL ABSORPTION OF BENZO(A)PYRENE AT 24 HOURS

Source[1]	% BaP Absorbed at 24 hr	Preparation	Vehicle	Dose
Yang et al 1986	6	Rat in vivo	Acetone	9-10 ug/cm^2
	17	Rat in vitro	Acetone	9-10 ug/cm^2
Yang et al 1989	6	Rat in vivo	1 ppm BaP in crude oil	90 ug/cm^2
	12	Rat in vitro	1 ppm BaP in crude oil	90 ug/cm^2
Kao et al 1984	24	Mouse in vitro	Acetone	1 ug/cm^2
Kao et al 1985	3	Human in vitro	Acetone	2 ug/cm^2
Kao et al 1988	10	Mice in vitro	Acetone	2 5 ug/cm^2
Wester 1990	24	Human in vitro	Acetone	10 ppm
	51	Rhesus monkey in vivo	Acetone	10 ppm
Average % Absorbed	17			
95% UCL % Absorbed	25.68			

Kao et al 1984 Toxicology and Applied Pharmacology 75 289-298
Kao et al 1985 Toxicology and Applied Pharmacology 81 502-516
Kao et al 1986 Toxicology and Applied Pharmacology 94 93-103
Yang et al 1986 Toxicology and Industrial Health 2 409-416
Yang et al 1989 Bulletin of Environmental Contaminants and Toxicology 43 207-214
Wester et al 1990 Fundamentals of Applied Toxicology 15 510-516

(1) The cited studies are from the references cited in EPA 1992 Dermal Exposure Assessment Principles and Applications (EPA/800/8-91/011B) Studies not cited in this table include those conducted in previously frozen tissue and Sanders et al 1984 (in vivo percutaneous absorption of BaP in mouse) The latter was excluded because mouse skin has been shown to be 2 5 to 5 times more permeable than skin of other species, including humans (Kao et al 1985, as cited in EPA 1992 Dermal Exposure Assessment Principles and Applications)

TABLE B-6
COMPARISON TO RISK-BASED SCREENING CONCENTRATIONS
GROUNDWATER COMPOUNDS AT LESS THAN 5% FREQUENCY OF DETECTION
CARCINOGENIC AND NON-CARCINOGENIC EFFECTS

Equations Cs-c = Risk / (IForal-c x SForal)
Cs-nc = (HI x RfDoral) / IForal-nc

Where
Cs-c = Cancer Risk-Based Screening Concentration
Cs-nc = Noncancer Risk-Based Screening Concentration
Risk = Target Risk Level of 1 E-6
HI = Target Hazard Index = 1
IForal-c = Oral Intake Factor for Carcinogens (Table B-1)
IForal-nc = Oral Intake Factor for Noncarcinogens (Table B-1)
SForal = Oral Slope Factor
RfDoral = Oral Reference Dose
RBC-c = Risk-based concentration at 1E-6 target excess cancer risk
RBC-nc = Risk based concentration at HI = 1

CHEMICAL	SForal (mg/kg-d)^-1	RfDoral mg/kg-d	IForal-c L/kg-d	RBC-c mg/L	IForal-nc L/kg-d	RBC-nc mg/L	CS-c 1000 x RBC-c	Cs-nc 1000 x RBC-nc	Maximum Conc. mg/L	Maximum Conc. > Cs
1,1,2,2-tetrachloroethane	2.0E-01		1 17E-02	4 3E-04	2 7E-02		4 3E-01		1 80E-01	NO
1,1,2-trichloroethane	5 7E-02	4 0E-03	1 17E-02	1 5E-03	2 7E-02	1 5E-01	1 5E+00	1 5E+02	2.10E-02	NO
1,2,3-trichloropropane		6 0E-03	1 17E-02	-	2 7E-02	2 2E-01		2.2E+02	2.00E-03	NO
1,2,4-trichlorobenzene	-	1 0E-02	1 17E-02		2 7E-02	3 6E-01		3 6E+02	2.00E-03	NO
1,2-dibromoethane	8 5E+01		1 17E-02	1.0E-06	2 7E-02		1 0E-03		1 30E-02	[redacted]
1,2-dichlorobenzene		9 0E-02	1 17E-02		2 7E-02	3 3E+00	-	3.3E+03	1 00E-04	NO
1,2-dichloroethane	9 1E-02	-	1 17E-02	9 4E-04	2.7E-02		9 4E-01		7 30E-03	NO
1,2-dimethylbenzene (o-xylene)	-	2 0E+00	1 17E-02		2 7E-02	7 3E+01		7 3E+04	2 00E-04	NO
1,3-dimethylbenzene (m-xylene)		2 0E+00	1 17E-02		2 7E-02	7 3E+01		7 3E+04	3.00E-04	NO
1,4-dichlorobenzene	2 4E-02		1 17E-02	3 6E-03	2 7E-02		3 6E+00		3.00E-04	NO
4-methyl-2-pentanone	-	5 0E-02	1 17E-02		2 7E-02	1 8E+00		1 8E+03	1 00E-02	NO
benzene	2.9E-02		1 17E-02	2.9E-03	2 7E-02		2.9E+00		5 00E-03	NO
bromoform	7 9E-03	2 0E-02	1 17E-02	1 1E-02	2 7E-02	7 3E-01	1.1E+01	7 3E+02	6 00E-03	NO
chlorobenzene		2 0E-02	1 17E-02		2 7E-02	7 3E-01		7 3E+02	2 00E-02	NO
chloromethane	1 3E-02		1 17E-02	6 6E-03	2 7E-02		6.6E+00		5 00E-03	NO
cis-1,3-dichloropropene		3 0E-04	1 17E-02		2 7E-02	1 1E-02		1 1E+01	1 70E+00	NO
dibromomethane		1 0E-02	1 17E-02		2 7E-02	3 6E-01		3 6E+02	1 70E+00	NO
dichlorodifluoromethane		2 0E-01	1 17E-02		2 7E-02	7 3E+00		7 3E+03	6 00E-04	NO
ethylbenzene	-	1 0E-01	1 17E-02		2 7E-02	3 6E+00		3 6E+03	2.00E-02	NO
hexachlorobutadiene	7 8E-02		1 17E-02	1 1E-03	2.7E-02		1 1E+00		1 20E-03	NO
o-chlorotoluene	-	2 0E-02	1 17E-02		2.7E-02	7 3E-01		7 3E+02	3 00E-03	NO
1,2-dibromo-3-chloropropane	1 4E+00	-	1 17E-02	6 1E-05	2.7E-02		6 1E-02	-	4 20E-03	NO
styrene	-	2 0E-01	1 17E-02	-	2.7E-02	7 3E+00		7 3E+03	1 00E-02	NO
vinyl chloride	1 9E+00	-	1 17E-02	4 5E-05	2.7E-02	-	4 5E-02		8 60E-01	[redacted]
di-n-butylphthalate	-	1 0E+01	1 17E-02		2.7E-02	3 6E+02		3 6E+05	3 00E-03	NO

TABLE B-7
COMPARISON TO RISK-BASED SCREENING CONCENTRATIONS
SOIL COMPOUNDS AT LESS THAN 5% FREQUENCY
CARCINOGENIC EFFECTS

Equation **Cs = Risk / [((IForal +IFderm) x SF oral)+ (IFinh x SF inh)]**

Where

Cs = Screening concentration in soil (mg/kg)
Risk = Target cancer risk level
SF oral = Slope Factor for oral route
SF inh = Slope Factor for inhalation exposure route
IForal = Oral Intake Factor (Table B-2)

IFderm = Dermal Exposure Intake Factor (Table B-3)
IFinh = Inhalation Exposure Intake Factor (Table B-4), incorporating PM10 air concent
PM Air = 37 μg/m^3 (Site-specific, assumed 100% PM10)
RBC = Risk-based screening concentration at 1 E-6 target risk

Target Risk = 1 0E-06 1 0E-03

CHEMICAL	IFderm kg/kg-d	IForal kg/kg-d	PM Air Conc. kg/m^3	PM IFinh kg/kg-d	SF oral (mg/kg-day)^-1	SF inh (mg/kg-day)^-1	RBC (mg/kg)	Cs (1000 X RBC) (mg/kg)	Maximum Conc. (mg/kg)	Maximum Conc. > Cs?
Subsurface Soil										
benzene	4 2E-07	7 8E-07	0	0	2 9E-02	2 9E-02	2 9E+01	2 9E+04	1 2E-02	NO
chloroform	4 2E-07	7 8E-07	0	0	6 1E-03	8 0E-02	1 4E+02	1 4E+05	8 8E+00	NO
carbon tetrachloride	4 2E-07	7 8E-07	0	0	1 3E-01	5 3E-02	6 4E+00	6 4E+03	1 4E+02	NO
pentachlorophenol	4 2E-07	7 8E-07	3 7E-08	3 3E-09	1 2E-02	-	6 9E+01	6 9E+04	9 5E-02	NO
1,4-dichlorobenzene	4 2E-07	7 8E-07	3 7E-08	3 3E-09	2 4E-02	-	3 5E+01	3 5E+04	4 3E-02	NO
benzo(a)pyrene	4 2E-07	7 8E-07	3 7E-08	3 3E-09	5 8E+00	6 1E+00	1 4E-01	1 4E+02	4 8E-01	NO
chrysene	4 2E-07	7 8E-07	3 7E-08	3 3E-09	5 8E-02	-	1 4E+01	1 4E+04	4 2E-01	NO
benzo(a)anthracene	4 2E-07	7 8E-07	3 7E-08	3 3E-09	5 8E-01	-	1 4E+00	1 4E+03	5 3E-01	NO
benzo(b)fluoranthene	4 2E-07	7 8E-07	3 7E-08	3 3E-09	5 8E-01	-	1 4E+00	1 4E+03	8 2E-01	NO
hexachlorobutadiene	4 2E-07	7 8E-07	3 7E-08	3 3E-09	7 8E-02	7 8E-02	1 1E+01	1 1E+04	1 7E-01	NO
hexachloroethane	4 2E-07	7 8E-07	3 7E-08	3 3E-09	1 4E-02	1 4E-02	5 9E+01	5 9E+04	1 1E+00	NO
indeno(1,2,3-c,d)pyrene	4 2E-07	7 8E-07	3 7E-08	3 3E-09	5 8E-01	-	1 4E+00	1 4E+03	3 3E-01	NO
4,4'-DDT	4 2E-07	7 8E-07	3 7E-08	3 3E-09	3 4E-01	3 4E-01	2 4E+00	2 4E+03	1 4E-01	NO
Aroclor-1254	4 2E-07	7 8E-07	3 7E-08	3 3E-09	7 7E+00	-	1 1E-01	1 1E+02	8 9E+00	NO
Surface Soil										
Aroclor 1254	4 2E-07	7 8E-07	3 7E-08	3 3E-09	7 7E+00	-	1 1E-01	1 1E+02	9 7E-01	NO
Aroclor 1260	4 2E-07	7 8E-07	3 7E-08	3 3E-09	7 7E+00	-	1 1E-01	1 1E+02	6 6E-01	NO

TABLE B-8
COMPARISON TO RISK-BASED SCREENING CONCENTRATIONS
SOIL COMPOUNDS AT LESS THAN 5% FREQUENCY
NON-CARCINOGENIC EFFECTS

Equation $Cs = (HI) / [((IForal + IFderm) / RfD\ oral) + (IFinh / RfD\ inh)]$

Where
Cs = Screening concentration in soil (mg/kg)
HI = Target Hazard Index
IForal = Oral Intake Factor
IFderm = Dermal Exposure Intake Factor
IFinh = Inhalation Exposure Intake Factor

RfD oral = Oral Reference Dose, mg/kday
RfD inh = Inhalation Reference Dose, mg/kg-day
PM AIR = 37g/m^3 (Site-Specific value assumed to be 100% PM10))
RBC = Risk-based screening concentration at 1 0 target HI

CHEMICALS	IFderm kg/kg-d	IForal kg/kg-d	PM Air Conc. kg/m^3	PM IFinh kg/kg-d	Oral RfD	Inhalation RfD	RBC (mg/kg)	Cs (1000 X RBC) (mg/kg)	Maximum Conc. (mg/kg)	Maximum Conc. > Cs?
					Target HI =		1	1000		
Subsurface Soil										
chloroethane	1.00E-06	1.80E-06	3.70E-08	7.59E-09		3	3.95E+08	3.95E+11	5.00E-02	NO
chloroform	1.00E-06	1.80E-06	3.70E-08	7.59E-09	1.00E-02		3.57E+03	3.57E+06	8.80E+00	NO
cis-1,3-dichloropropene	1.00E-06	1.80E-06	3.70E-08	7.59E-09	3.00E-04	5.00E-03	1.07E+02	1.07E+05	6.00E-03	NO
ethylbenzene	1.00E-06	1.80E-06	3.70E-08	7.59E-09	1.00E-01	3.00E-01	3.57E+04	3.57E+07	7.80E-01	NO
styrene	1.00E-06	1.80E-06	3.70E-08	7.59E-09	2.00E-01	3.00E-01	7.13E+04	7.13E+07	1.70E-02	NO
carbon tetrachloride	1.00E-06	1.80E-06	3.70E-08	7.59E-09	7.00E-04		2.50E+02	2.50E+05	1.40E+02	NO
1,2-dichloroethene	1.00E-06	1.80E-06	3.70E-08	7.59E-09	9.00E-03		3.21E+03	3.21E+06	9.00E-02	NO
pentachlorophenol	1.00E-06	1.80E-06	3.70E-08	7.59E-09	3.00E-02		1.07E+04	1.07E+07	9.50E-02	NO
fluoranthene	1.00E-06	1.80E-06	3.70E-08	7.59E-09	4.00E-02		1.43E+04	1.43E+07	1.00E+00	NO
pyrene	1.00E-06	1.80E-06	3.70E-08	7.59E-09	3.00E-02		1.07E+04	1.07E+07	1.30E+00	NO
1,4-dichlorobenzene	1.00E-06	1.80E-06	3.70E-08	7.59E-09		2.00E-01	2.64E+07	2.64E+10	4.30E-02	NO
acenaphthene	1.00E-06	1.80E-06	3.70E-08	7.59E-09	6.00E-02		2.14E+04	2.14E+07	2.80E-01	NO
di-n-octyl phthalate	1.00E-06	1.80E-06	3.70E-08	7.59E-09	2.00E-02		7.14E+03	7.14E+06	2.60E-01	NO
naphthalene	1.00E-06	1.80E-06	3.70E-08	7.59E-09	4.00E-02		1.43E+04	1.43E+07	2.00E+00	NO
benzoic acid	1.00E-06	1.80E-06	3.70E-08	7.59E-09	4.00E+00		1.43E+06	1.43E+09	4.00E-01	NO
anthracene	1.00E-06	1.80E-06	3.70E-08	7.59E-09	3.00E-01		1.07E+05	1.07E+08	2.60E-01	NO
butyl benzyl phthalate	1.00E-06	1.80E-06	3.70E-08	7.59E-09	2.00E-01		7.14E+04	7.14E+07	5.20E-01	NO
diethyl phthalate	1.00E-06	1.80E-06	3.70E-08	7.59E-09	8.00E-01		2.86E+05	2.86E+08	5.20E-02	NO
hexachloroethane	1.00E-06	1.80E-06	3.70E-08	7.59E-09	1.00E-03		3.57E+02	3.57E+05	1.10E+00	NO
4,4 -DDT	1.00E-06	1.80E-06	3.70E-08	7.59E-09	5.00E-04		1.79E+02	1.79E+05	1.40E-01	NO

APPENDIX C
OU 2 DOMESTIC WATER SUPPLY SIMULATIONS

OU-2 DOMESTIC WATER SUPPLY SIMULATIONS

The results of computer simulations of domestic water production capabilities from subsurface units beneath OU-2 at the Rocky Flats Plant, Golden, Colorado

This work was performed by the Earth Resources Division for the Remediation Programs Division in support of risk analysis studies.

September 10, 1992

INTRODUCTION

To investigate the water production capabilities of the near surface hydrostratigraphic units beneath Operable-unit 2 at the Rocky Flats Plant several transient pumping computer simulations were performed. These simulations were designed to determine whether these units could produce sufficient water to supply a hypothetical four-member household. A daily pumping requirement of 240 gallons per day (gpd) was assumed based on a daily water requirement of 60 gallons per person

Independent simulations were performed for three different hydrostratigraphic units Models were constructed for the Rocky Flats Alluvium, hillslope colluvial materials, and an unconfined Arapahoe sandstone unit representing the #1 sandstone beneath OU-2. The Rocky Flats Alluvium and hillslope colluvial materials were not considered reliable water sources but were included in the simulations since they comprise the upper-most hydrostratigraphic units and have been impacted by plant activities The Arapahoe sandstone unit was included because it was considered to be the best prospect for producing water from the Arapahoe Formation. The claystones of the Arapahoe formation were not considered good prospects for water and as such were not modeled.

METHOD

Simulations were performed using the USGS MODFLOW groundwater flow simulation package (McDonald and Harbaugh, 1988). Input parameters common to all simulations are listed in table 1 Separate simulations were done for the Rocky Flats Alluvium, hillslope colluvium and the Arapahoe sand unit. A listing of the input parameters for these simulations are given in tables 2, 3, and 4. Simulations were run using a daily time-frame until the pumping-well grid cell went dry or the end of the simulation (365 days) was reached.

Each day of the transient simulation was divided into two periods and each period was divided into two timesteps. The first 2.7 hours of each day was used as a pumping period. It was assumed that the household maintained water storage capabilities and that this pumping period was used to replenish the water storage system. A pumping rate of 1.5 gpm was used. This rate is below the 3-5 gpm rate commonly used for domestic wells and as such is conservative. The pumping period was based on the total daily water requirement (240 gal.) and the pumping rate (1.5 gpm)

$$240 \text{ gal}/(1.5 \text{ gal/min} \bullet 60 \text{ min/hr}) = 2.7 \text{ hrs}$$

The remaining 21.3 hours of each day allowed water level recovery to take place.

The pumping well was located at the center of the grid cell array. A variable grid spacing ranging from 5 feet at the well to 50 feet at the boundaries was used to provide realistic drawdown conditions near the well. The grid spacing for each scenario are given in tables 2, 3, and 4.

Boundary conditions were either constant head (equal to the initial head) or no-flow depending on the scenario. For the Rocky Flats Alluvium and hillslope colluvium scenarios constant head boundaries were used at all boundaries. For the Arapahoe sandstone simulation the modeling grid was intended to represent a discontinuous channel sand deposit. To implement this configuration no-flow boundaries were placed along two parallel sides of the grid with constant head boundaries along the other two sides

Table 1
Modeling parameters common to all scenarios

PARAMETER	VALUE	SOURCE
Water Requirement	240 gpd	Based on 60 gal/person/day
Pumping Rate	1 5 gpm	Assumed
Pumping Time per Day	2.7 hrs	Based on pumping rate
X to Y Anisotropy	1 (isotropic)	Assumed

ROCKY FLATS ALLUVIUM SCENARIO

Scenario specific parameters for the Rocky Flats Alluvium simulation are given in table 2. The modeling grid for this scenario consisted of a 19 by 19 grid cell array with the pumping well at the center of the grid and constant head boundaries (equal to the initial head) along each edge of the grid. The grid spacing in feet for the x and y directions increased from the well as follows 5_{well}-7-10-15-25-35-50-50-50-$50_{boundary}$ (see figure 1) The hydraulic conductivity value comes from the recent OU-2 aquifer pump testing program. The value used represents the geometric mean of the results from two test locations. The specific yield came from lab analyses of core samples and example values from the literature for fine-grained materials (Fetter, 1980, pg. 68). The initial saturated thickness represents the historical average for well 1787 which is within OU-2. During initial pump test planning this well was observed to have the greatest alluvial saturated thickness and therefore should represent the most reliable OU-2 alluvial water source

Table 2
Modeling Parameters for Rocky Flats Alluvium

PARAMETER	VALUE	SOURCE
Hydraulic Conductivity	1.6 ft/day	OU-2 pumping test
Specific Yield	0.10	Lab analyses/literature
Grid Spacing (variable)	from 5 to 50 ft	Assumed
Hydrogeologic Unit Condition	Unconfined	On-site observation
Initial Saturated Thickness	7.2 ft	Observation wells
Boundary Conditions	Constant head	Assumed

Results

For the Rocky Flats Alluvium scenario the pumping-well grid cell went dry within one to two hours after pumping started on the first day of the simulation. These results are consistent with the low pumping rates (0.3 - 0 056 gpm) required during field pump testing to avoid excessive drawdown.

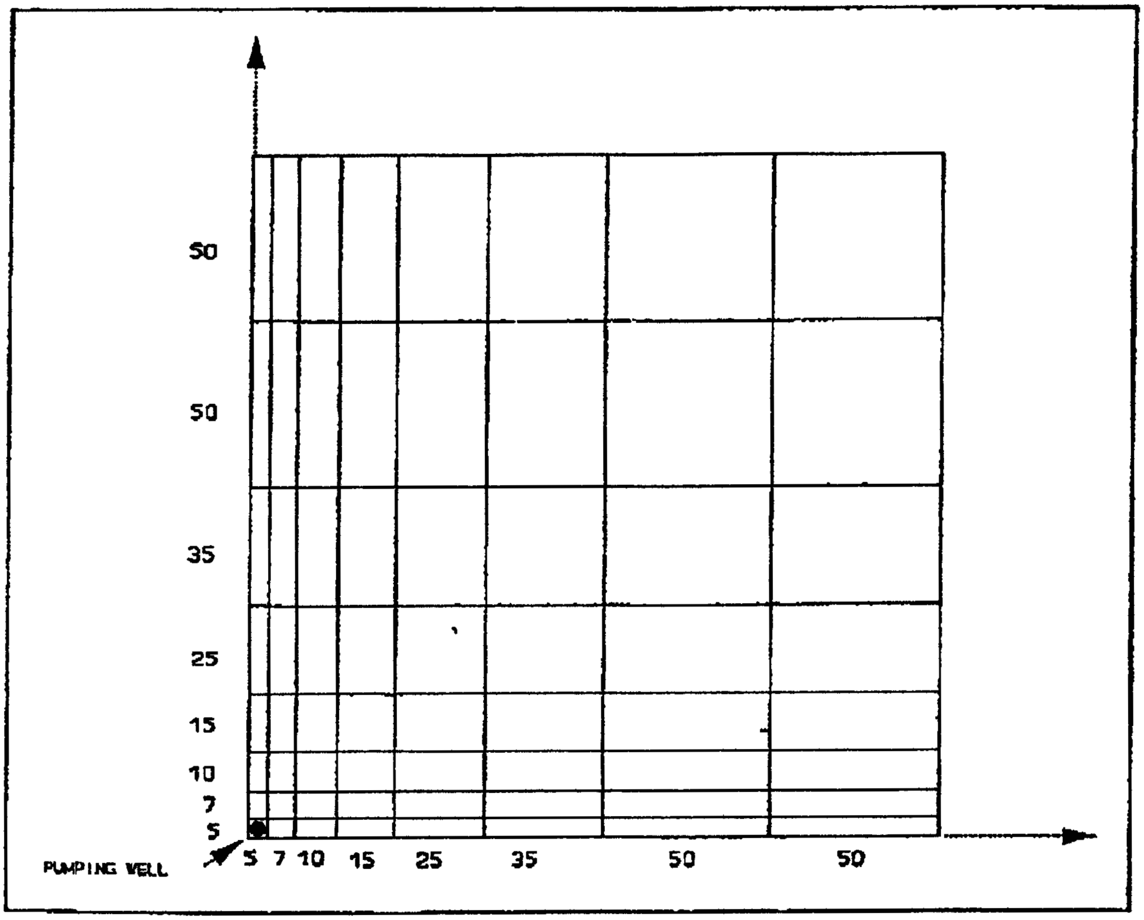

Figure 1. Figure shows 1/4 (upper right-hand quadrant) of an example model grid. In model well is at center of grid. Grid spacings in feet The number of grid nodes for each model may differ, but grid spacings are similar Not to scale.

HILLSLOPE COLLUVIUM SCENARIO

Scenario specific parameters for the hillslope colluvium simulation are given in table 3. The modeling grid for this scenario consisted of a 19 by 19 grid cell array with the pumping well at the center of the grid and constant head boundaries (equal to the initial head) along each edge of the grid. The grid spacing in feet in the x and y directions increased from the well as follows 5_{well}-7-10-15-25-35-50-50-50-$50_{boundary}$ (see figure 1). Because there were no hydraulic conductivity values for OU-2 colluvium, data from slug-tests in colluvial material from OU-1 were used. These values should be representative of conditions in OU-2 since OU-1 and OU-2 are physically adjacent to each other. The specific yield came from lab analyses of core samples and example values from the literature for fine-grained materials (Fetter, 1980, pg 68). The initial saturated thickness represents the average for well 0687 which is within OU-2. Comparisons of water level data indicate this well has historically had relatively large saturated thicknesses and would therefore represent conditions most promising for OU-2 colluvial water production.

Table 3
Modeling Parameters for Hillslope Colluvium

PARAMETER	VALUE	SOURCE
Hydraulic Conductivity	0 17 ft/day	OU-1 field testing
Specific Yield	0.10	Lab analyses/literature
Grid Spacing (variable)	from 5 to 50 ft	Assumed
Hydrogeologic Unit Character	Unconfined	On-site observation
Initial Saturated Thickness	3 6 ft	Observation wells
Boundary Conditions	Constant head	Assumed

Results

For the hillslope colluvium scenario the pumping-well grid cell went dry within one hour after pumping started on the first day of the simulation. This is consistent with the low hydraulic conductivity and small saturated thickness observed for colluvial materials.

ARAPAHOE SANDSTONE SCENARIO

Scenario specific parameters for the Arapahoe Sandstone simulation are given in table 4. The modeling grid for this scenario consisted of a grid cell array of 23 rows by 31 columns with the pumping well at the center of the grid. The rectangular shape of the modeling grid represents the elongate physical shape of the sandstone unit as reconstructed from borehole information. Constant head boundaries (equal to the initial head) were used along the first and last columns of the grid with no-flow boundaries set along the other two edges. The grid spacing in feet in the x and y directions increased from the well as follows 5_{well}-7-10-15-25-35-50-50- ... -$50_{boundary}$ (see figure 1). The hydraulic conductivity value came from OU-2 aquifer pump testing. The specific yield is assumed equal to the effective porosity computed for this sandstone from the OU-2 tracer test program. The initial saturated thickness represents the historic average for well 3687 which was included in the OU-2 aquifer test program for the #1 Arapahoe Sandstone.

Table 4
Modeling Parameters for Arapahoe Sandstone

PARAMETER	VALUE	SOURCE
Hydraulic Conductivity	1.1 ft/day	OU-2 field testing
Specific Yield	0.12	OU-2 tracer testing
Grid Spacing (variable)	from 5 to 50 ft	Assumed
Hydrogeologic Unit Condition	Unconfined	On-site observation
Initial Saturated Thickness	33.7 ft	Observation wells
Boundary Conditions	Constant head & No flow	Assumed

Results

For the Arapahoe Sandstone scenario the pumping well was able to meet the water requirement without dewatering the pumping-well grid cell The maximum draw down observed at the pumping well after 365 days was 3 2 feet indicating that the aquifer was not highly stressed at this pumping rate. These results are consistent with OU-2 aquifer testing that resulted in approximately seven feet of draw down after five days of continuous pumping at 1.6 gpm.

SUMMARY OF FINDINGS

Based on groundwater flow simulation results neither the Rocky Flats Alluvium nor the hillslope colluvium materials within OU-2 are capable of producing sufficient water to support a four-member household consuming 240 gallons per day. Using a 2.7 hour daily pumping period and a rate of 1.5 gpm, both the alluvium and the colluvium wells would be pumped dry within one day (table 5). In contrast, a well within the Arapahoe sandstone beneath OU-2 would appear to provide a reliable water resource at the required rates given above. The well grid-point in this simulation experienced only minimal drawdown after one year of daily-pumping cycles.

Table 5

Summary of simulation results

FORMATION	WATER PRODUCTION DAYS
Rocky Flats Alluvium	<1
Hillslope Colluvium	<1
Arapahoe Sandstone	>365

To investigate the water resource potential for the OU-2 Arapahoe sandstone unit the total water available from this unit was computed (table 6). The average spatial dimensions of the sandstone unit were taken from isopach maps constructed from well and borehole information. The average saturated thickness is an assumed value derived from observational water level data and sandstone thickness information. The specific yield is assumed equal to the effective porosity as used above

Assuming an annual water requirement of 2,920 cubic feet (equivalent to 60 gal/day • 365 days) there appears to be sufficient water volume in the sand to support ten four-person families for approximately 54 years (6,300,000 cu ft / (2,920 cu ft/person/year • 40 persons) = 53 9 years). This assumes complete desaturation of the aquifer (which is virtually impossible) and does not account for any external recharge to the aquifer.

Table 6

Arapahoe Sandstone Water Resource Evaluation

DESCRIPTION	VALUE	UNITS
Length of sand	4,200	ft
Width of sand	500	ft
Sat thickness of sand	25	ft
Total saturated sand vol	52,500,000	cu ft
Specific yield	0.12	
Total water volume	6,300,000	cu ft
Daily water need	60	gal/person/day
Daily water need	8	cu ft/person/day
Annual water need	2,920	cu ft/person/year
Available water	2,158	person/years

References

Fetter, C W. Jr , 1980, Applied Hydrogeology, Merrill Publishing Company, Columbus, 488 p.

McDonald, Michael G. and Harbaugh, Arlen W , 1988, Techniques of Water-Resources Investigations of the United States Geological Survey, Book 6, Chapter A1, A Modular Three-dimensional Finite-difference Groundwater Flow Model.

APPENDIX D

DISSOLVED METALS AND RADIONUCLIDES
IN THE NO 1 SANDSTONE
BACKGROUND COMPARISON

TABLE D-1
ROCKY FLATS PLANT OU-2
95% UTL COMPARISON
DISSOLVED METALS IN GROUNDWATER, μg/L
NO. 1 SANDSTONE

Analyte	OU-2 Detected Min	OU-2 Detected Max	OU-2 Detected DF %	Bknd Max	Background 95% UTL(1)	% of OU-2 data > 95% UTL(2)
Aluminum	20	367	85	256	195	2
Antimony	9	56	15	60	52	5
Arsenic	1	1	6	10	8	0
Barium	82	352	100	200	174	82
Beryllium	1	3	5	5	4	0
Cadmium	1	98	13	5	5	2
Cesium	30	100	19	1000	759	0
Chromium	3	23	19	16	13	8
Cobalt	3	3	1	50	36	0
Copper	2	9	19	25	20	0
Lead	1	2	5	10	5	0
Lithium	2	38	79	100	112	0
Manganese	1	1240	68	30	27	28
Mercury	0 21	0 25	2	1 2	0 64	0
Molybdenum	3	16	36	100	63	0
Nickel	2	23	22	40	30	0
Selenium	1	10	48	6	5	2
Silver	2	4	7	10	10	0
Strontium	253	744	98	1050	1026	0
Thallium	1	2	6	10	9	0
Tin	14	34	7	100	75	1
Vanadium	3	10	76	50	36	2
Zinc	2	56	69	81	40	5

(1) Background Geochemical Characterization Report, Rocky Flats Plant EG&G 1992
(2) UTL comparison is performed using the detection limit for results reported as non-detect
Therefore, the maximum detected value in OU-2 can be below the 95% UTL of background even through the UTL comparison shows that a certain percentage of OU-2 data exceeds the 95% UTL of background

DF = Detection frequency

TABLE D-2
ROCKY FLATS PLANT OU-2
95% UTL COMPARISON
DISSOLVED RADIONUCLIDES IN GROUNDWATER, pCi/L
NO 1 SANDSTONE

Analyte	OU-2 Detected Min	OU-2 Detected Max	OU-2 Detected DF	Bknd Max	Bknd 95% UTL (1)	% OU-2 data > 95% UTL
Americium-241	0 005	0 04	4/4	-	NE	*
Cesium-137(2)	0 2	1 5	5 /12	-	NE	*
Plutonium-239/240	0 0006	0 01	4/6	-	NE	*
Radium-226	0 3	1 0	19/19	0 43	0 86	5 3
Strontium-89/90	0 02	1 6	87/101	-	NE	*
Tritium	6 7	740	73/87	-	NE	*
Uranium-233/234	0 67	12	101/101	199 5	142 00	0
Uranium-235	0 02	0 43	75/101	4 8	9 3	0
Uranium-238	0 5	9.4	97/97	135 6	116 0	0

(1) Background Geochemical Characterization Report, Rocky Flats Plant, EG&G 1992
Note No background data for radionuclides in the No 1 Sandstone are available Background UTLs are calculated using data from the alluvium and colluvium
(2) Includes "total radioacive cesium" (6 analyses)

DF = Detection frequency (no detects/no samples)
NE = not evaluated Data insufficient to calculate 95% UTL
* Comparison cannot be made.

TABLE D-3
ROCKY FLATS PLANT OU-2
ANOVA COMPARISON
DISSOLVED METALS IN GROUNDWATER, µg/L
NO. 1 SANDSTONE

Analyte	Background Mean	Background SD	OU-2 Data Mean	OU-2 Data SD	Norm Dist?	Test	Result (Chi-Square)	P =	Significantly Different?	BKG Mean > OU2 Mean[1]	Consider Further?
Aluminum	61	63	59	55	No	Kruskal	2 06	0 15	N	Y	N
Antimony	19	15	24	12	No	Kruskal	17 21	<0 01	Y	N	Y
Arsenic	3	2	4	2	No	Kruskal	14 08	<0 01	Y	N	Y
Barium	93	38	144	59	No	Kruskal	50.04	<0 01	Y	N	Y
Beryllium	1	1	2	1	No	Kruskal	19 15	<0 01	Y	N	Y
Cadmium	3	1	3	9	No	Kruskal	1 91	0 17	N	N	N
Cesium	220	247	319	212	No	Kruskal	12 66	<0 01	Y	N	Y
Chromium	6	3	5	3	No	Kruskal	1 24	0.26	N	Y	N
Cobalt	8	14	17	12	No	Kruskal	21 12	<0 01	Y	N	Y
Copper	7	6	8	5	No	Kruskal	10.59	<0 01	Y	N	Y
Lead	2	2	1	1	No	Kruskal	12 16	<0 01	Y	Y	N
Lithium	44	32	22	25	No	Kruskal	33 20	<0 01	Y	Y	N
Manganese	10	8	74	181	No	Kruskal	6 44	0 01	Y	N	Y
Mercury	0 2	0 2	0 12	0 12	No	Kruskal	74 22	<0 01	Y	N	Y
Molybdenum	15	22	41	45	No	Kruskal	12.56	<0 01	Y	N	Y
Nickel	8	10	13	9	No	Kruskal	34.57	<0 01	Y	N	Y
Selenium	2	1	2	1	No	Kruskal	7.24	<0 01	Y	N	Y
Silver	4	3	4	2	No	Kruskal	4 3	0 04	Y	N	Y

TABLE D-3
(Concluded)

	Background		OU-2 Data								
Analyte	Mean	SD	Mean	SD	Norm Dist?	Test	Result (Chi-Square)	P =	Significantly Different?	BKG Mean > OU2 Mean[1]	Consider Further?
Strontium	394	296	430	192	No	Kruskal	15 41	<0 01	Y	N	Y
Thallium	3	3	4	2	No	Kruskal	17.55	<0 01	Y	N	Y
Tin	24	24	62	43	No	Kruskal	29 38	<0 01	Y	N	Y
Vanadium	8	13	7	8	No	Kruskal	1 08	0.30	N	Y	N
Zinc	12	13	11	11	No	Kruskal	0 94	0 33	N	Y	N

[1] If the background mean is higher than OU-2 mean, a statistically significant difference ($P < 0.05$) is not applicable

TABLE D-4
ROCKY FLATS PLANT OU-2
ANOVA COMPARISON
DISSOLVED RADIONUCLIDES IN GROUNDWATER, pCi/L
NO. 1 SANDSTONE

	Background		OU-2 Data								
Analyte	Mean	SD	Mean	SD	Norm Dist?	Test	Result (Chi-Square)	P =	Significantly Different?	BKG Mean >OU2 Mean[1]	Consider Further?
Americium 241	--	--	0 02	0 04	No	Kruskal	--	--	--	--	Y
Cesium 137[3]	--	--	0 44	0 40	No	Kruskal	--	--	--	--	Y
Plutonium 239, 240	--	--	<0 01	<0 01	No	Kruskal	--	--	--	--	Y
Radium 226	0.24	0 14	0.58	0 16	No	Kruskal	8.53	<0 01	Y	N	Y
Strontium 89,90	--	--	0 36	0.31	No	Kruskal	--	--	--	--	Y
Tritium	760 7[2]	--	169	156	No	Kruskal	2 94	0.09	N	--	N
Uranium 233, 234	24	53	3	2	No	Kruskal	0 38	0.35	N	Y	N
Uranium 235	2	2	0 10	0 09	No	Kruskal	16.94	<0 01	Y	Y	N
Uranium 238	21	40.5	2	1	No	Kruskal	1 07	0 30	N	Y	N

[1] If the background mean is higher than OU-2 data mean, a statistically significant difference (P<0 05) is not applicable
[2] One background data point
[3] Includes "total radioactive cesium" analyses
-- No data